

XIX.—*Contributions towards the Knowledge of the Fossil Flora in India.*

- I. *On some Fossil Plants from the Damuda Series in the Raniganj Coalfield, collected by MR. J. WOOD-MASON.—By OTTO KAR FEISTMANTEL, M. D., Palæontologist, Geological Survey of India.*

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(With Plates XV—XXI.)

The present paper is the result of the examination of a fine suite of fossil plants which has lately been brought down from Raniganj by Mr. J. Wood-Mason.\* The collections in the museum of the Geological Survey contain it is true also a good many specimens from the same coalfield and from all other localities, which on a future occasion shall all be worked out together; but Mr. Wood-Mason's collection contributes so much to our knowledge of this very important flora—containing as it does not only some perfectly new forms but also good and better specimens of some of the species already found—as to be of sufficient interest to merit separate description, and this I have undertaken at the special request of Mr. Wood-Mason.

The Raniganj coalfield belongs to that portion of the Indian sedimentary rocks which constitute the Damuda Series of the survey classification. These together with the overlying Panchet group form the lower portion of a whole system, which at first was designated the “Plant-bearing Series,” but which may more appropriately be termed the “Gondwana System,” the upper portion of which is formed by the Kach-Jabalpur and the Rajmahal group.

As the Damuda Series contains scarcely anything but plant-remains as relics of the life that existed during the period of its deposition, of course every contribution to the knowledge of that life is of high importance.

For although several papers have been written on this lower portion of the “Gondwana System,” yet till lately no sufficient evidence as to its age has been given.

We have several excellent papers on the geology of this series.† But the palæontological papers are ephemeral only and mostly of old date; and the plants described therein were far from sufficient to enable one to form a proper idea of the horizon. Later on, when the officers of the Geological Survey began their field-work, a great many specimens from the

\* See a short note on this subject in Rec. G. S. Ind. IX. 4.

† Mostly in the Memoirs of the Geological Survey of India.

Raniganj coalfield, and altogether from the Damudas, were collected; but until recently they remained unexamined and undescribed, so that all this excellent evidence could not be used to contradict the incorrect opinions that have prevailed as to the age of the Damudas.

I think it necessary first to mention some previous papers on the palæontology and geology of the formation under discussion, to show what is the state of our knowledge of the fossils of this series.

The first mention of fossil plants from Raniganj is to be found in Ad. Brongniart's papers, 'Prodrome d'une histoire des végétaux fossils' (1828) and 'Histoire des végét. foss.' (1828), wherein is described the genus *Glossopteris*. In the 'Prodrome' we find only one species of *Glossopteris* as *Glossopt. Browniana*, Bgt., from Australia and India. In the other work\* we find a thorough description of this genus and two varieties of the species distinguished as *Glossopt. Browniana*, Bgt. var. *a. australasica* and *Glossopt. Browniana*, Bgt. var. *β. indica*, the former from Australia, the latter from Raniganj, India.† Besides this is described *Glossopteris angustifolia*, Bgt., from the same locality (Raniganj), which Mr. Wood-Mason has rediscovered. This distinction of two varieties of *Glossopt. Browniana* according to locality was repeatedly adopted until Mr. Schimper‡ at last decided upon distinguishing them as different species; in which I go along with him. This author described the Indian *Glossopteris* as *Glossopt. indica*, Schimp., restricting the name *Glossopt. Browniana*, Bgt., to the Australian species. I myself could prove it again and will discuss it further.

These forms of *Glossopteris*, as Brongniart described them, were afterwards quoted again by subsequent authors, until Schimper made the above-mentioned division.

There are also some special papers on the plants of the Burdwan (Raniganj) field.

First we have Royle's paper,§ wherein four species of plants are figured; these were:—*Vertebraria indica*, Royle. (*Vertebraria radiata*, Royle), *Trizygia speciosa*, R., *Pecopteris Lindleyana*, R., *Glossopteris danaeoides*, R.

Of these *Vertebraria* has to remain; *Trizygia speciosa* is a *Sphenophyllum* with the specific name *Trizygia*||; *Pecopt. Lindleyana*, R., is an *Alethopteris* with the same specific name; *Glossopteris danaeoides*, R.

\* Hist. des végét. foss. 1828, p. 222, seq.

† Brongniart writes Rana-gunge.

‡ Schimper Traité de Pal. végét, I. p. 644, 645.

§ Royle, Illustrat. of the Botan. etc. in the Himalayan Mountains, 1839. Atlas, Pl. II.

|| Unger, Genera et species plant. foss. 1850, p. 71.

is, as everybody knows, a true *Taeniopteris*, Bgt., the veins being all quite free and parallel, and nowhere exhibiting any anastomosis.

What induced Mr. Unger\* to range this fossil with *Pecopteris*, I cannot understand, and I am the more astonished that Dr. Oldham† should have adopted his determination. But this *Glossopteris danaeoides*, Royle, is identical with what later McClelland‡ described as *Taeniopteris danaeoides*, also from the Burdwan coalfield. On Plate XV. fig. 1, 1a of McClelland's report two specimens are figured, which are however certainly incorrectly represented (as regards the distance of the veins apart), but which are without doubt typical *Taeniopteris*, Bgt. Mr. Oldham did not mention these figures of McClelland.

The rest of the figures in McClelland's report are of no use, as they are so badly drawn as to give no idea of the original specimens, *Sphenophyllum trizygia*, Ung. (*Sphenoph. speciosum*, McClell.) and *Vertebraria* alone being approximately correct; of *Glossopteris acaulis* (Pl. XIV. fig. 3) I have the original specimens, which in outline resemble McClelland's figures, but the venation is totally different.

The most exhaustive paper on the geology of the Raniganj coalfield is by Mr. W. T. Blanford.§ The author establishes in his report the following subdivisions of this coalfield :—

- I. Upper Panchet group.
- II. Panchet group.
- III. Damuda group.
  - a. Raniganj Series.
  - b. Iron Shales.
  - c. Lower Damudas.
- IV. Talchir group.

Mr. Blanford has given (*op. cit.* p. 31) a comparative table of these groups with their fossils; but from this it can be seen that the separation from a palæontological point of view is not quite so strict, especially if we consider that in the lower Damudas|| occur the same *Trizygia*, viz., *Sphenoph. trizygia*, and *Sphenopteris* as in the Raniganj group;¶ and should it hereafter be proved that *Schizoneura*, Schimp. also occurs in the lower beds, then it would be completely evident that these subgroups are not far apart in age. And as I will show further on, I also think the Talchir group is to be considered as belonging to the lower Damudas and

\* l. c., p. 170.

† Mem. Geol. Surv. Ind., Vol. II. p. 329.

‡ Rep. Geol. Surv. of India, 1848—49.

§ Mem. Geol. Surv. Ind. 1865, Vol. III.

|| From Talchir in Orissa.

¶ Of course besides *Phyllothea*, *Vertebraria*, and all the species of *Glossopteris*.

that all these subdivisions are from a palæontological point of view to be joined into one series, to which the name Damuda Series may be applied.

This view has been most distinctly expressed by Mr. Oldham in a paper\* adjoining Mr. W. T. Blanford's.

In the same paper Mr. T. Oldham proposes to replace the term "Lower Damuda" by the name "Barákur group", as this term "lower Damudas" would involve a group, which should be called "upper Damuda group;" which was originally described from the Nerbudda valley, but which was afterwards proved to belong to quite a different horizon.†

Previously to this paper by Mr. Blanford, we have one on the age of the several sedimentary beds in Central India and Bengal by Mr. Oldham,‡ wherein also for the Damuda Series, to which our Raniganj plants belong, a discussion is given.

But the fossils at that time were only provisionally examined and determined and only some forms were more remarkable, such as *Schizoneura*, Sch. Mong., *Vertebraria*, Royle, *Phyllothea*, Bgt., and *Glossopteris*, Bgt. All these fossils have been ever since in our collections; and although Mr. Oldham himself recognized the *Schizoneura* to be most characteristic of the Trias in Europe, and although *Phyllothea*, Bgt., is also very frequent in some Oolitic strata in Europe, yet the author relies solely upon the occurrence of the genus *Glossopteris*, Bgt., which is also reported from Australia, as indicating an analogous age; and Mr. Oldham maintained this opinion to the last.

Mr. Oldham also states that no *Teniopteris*, a genus which is so frequent in the Rajmahal Series, occurs in the Damúdas. But as we will see further on, *Teniopterides* are not quite rare, as Royle and McClelland have already figured them, and as later they have been found again,§ and Wood-Mason has brought several fine specimens.

Soon after Mr. Oldham's paper we have another by Sir Ch. Bunbury|| on some fossil plants from Nagpúr, wherein we also find some general conclusions. Sir C. Bunbury (*l. c.*, p. 345) says, referring to Mr. Oldham's paper: "Prof. Oldham is of opinion that the Rajmahal beds are mezozoic, the Damúda beds palæozoic. On this latter point I am not entirely prepared to go along with him. I still think for the reasons already given that the facies of this Nagpúr and Burdwan flora is rather mezozoic;" and further on he says, "The palæobotanical evidence is far

\* Mem. Geol. Surv. Ind. III. p. 197 seq. et 206, 207.

† This is the Jabalpúr group of the later classification.

‡ Mem. Geol. Surv. Ind. II. 1860, p. 299 seq.

§ Mr. Hughes has also brought some specimens from the Jherria coalfield.

|| Fossil flora of Nagpúr, Q. J. G. Soc. XVII, Pls. VIII—XII.



from unequivocal, and such as it is, might be outweighed by the discovery of a single well marked and thoroughly characteristic fish, shell or coral."

But nothing of this kind has as yet been found, while on the contrary many more plants have been discovered corroborating Sir Charles Bunbury's views as to the mezozoic age of the Damudas generally and particularly claiming a Triassic age for them.

But still the plant remains remained undescribed and unexamined, and although since 1871 there have been many unmistakeable proofs of the mezozoic age of this series, more than at the time when Mr. Oldham and Sir Charles Bunbury wrote on this subject, yet Mr. H. F. Blanford, in his recent paper on the age and correlation of the Plant-bearing Series in India, &c.,\* could make no use of all the evidence the plants afforded, and had of course to content himself with repeating all that had been previously said.

Of the plant-remains, which generally speaking form the principal portion of the fossils in the Gondwanas, Mr. H. F. Blanford repeats all the provisional names which Mr. Oldham had given,† and which were mostly only generic determinations: conclusions drawn from fossils not determined with certainty cannot, of course, be correct: they are mere suppositions and bear more a speculative character.

After having been engaged to the Survey of India, I examined the greatest portion of our Damúda fossils, as far as I thought it necessary to enable me to publish preliminary notes‡ on their relations and probable age.

I will not here repeat all the discussions and results, I will only say shortly that from the fossils, which are only plant-remains, I endeavoured to show that the flora of our Damúda Series has its analogies mostly in the mezozoic epoch of Europe, and especially in the Trias, although it contains richly represented the genus *Glossopteris*, which also occurs in Australia rarely in the lower, but more numerous in the upper coal-measures, which latter are certainly also mezozoic. Considering these notes only as preliminary I gave them only very briefly, postponing all detail for a future time.

But Mr. W. T. Blanford has endeavoured to illustrate the relations from his own point of view, and we find his paper in the same number of the Records as that in which my paper on the lower portion of the Damúdas was published. I need not here repeat what I had to remark,

\* Q. J. Geol. Soc. November 1875.

† Mem. Geol. Surv. Ind. II.

‡ Notes on several fossil floras in India. I. and II. Flora of Kach, and from the Rajmahal Hills in Records G. S. Ind. IX. 2. III. IV. V. The flora of the Panchet group, Damúda Series and Talchir group, Rec. G. S. Ind. IX. 3.

but I must only state that I felt obliged to explain shortly in another paper\* what I had omitted in the former one and postponed for a future occasion when describing the Damúda fossils. It is of course only very just that Mr. Blanford should have written this paper, but I think he will on the other side appreciate all the arguments which I have brought forward.

From my paper in the 4th number of Vol. IX. Rec. G. S. J., I will repeat some only of the most important points.

To the characteristic fossils, which I had already enumerated in my first note on the Damudas, such as *Schizoneura Gondwanensis*, Fstm. (triassic type), *Actinopteris Bengalensis*, Fstm. (mezozoic type), *Neuropteris valida*, Fstm. (triassic type), *Gangamopteris cyclopteroides*, Fstm. (mezozoic), *Voltzia heterophylla*, Bgt. (triassic), I added more palæontological evidence, consisting in the discovery of—

a. *Phyllothea*, in the real sense, in the Raniganj group, by which the analogy with the Kamthi group is rendered still more evident.

b. Some specimens of *Teniopteris* (*Macroteniopteris* and *Angiopteridium*?) from the Kamthis.

c. Some more specimens of *Sagenopteris* from the Godavari District and from Kurhurbari.†

d. A new *Gangamopteris* from the Kamthi beds.

e. A *Glossozamites* from the Kurhurbari coalfield.†

f. A *Nöggerathia* near *Vogesiacia*, Bronn, from the South Godavari district.

g. A *Voltzia heterophylla*, Bgt., again from the Kurhurbari coalfield.†

I think that these additions, which however do not include all that can be added, will modify to some extent Mr. W. T. Blanford's conclusion‡ “that the evidence, which connects the Damudas with the Australian carboniferous rocks is about equal to that which tends to show their relations with the Triassic§ rocks in Europe;” and that the evidence of a mezozoic age will be still further increased by the present contribution to the Flora of the Raniganj coalfield. The stratigraphical classification of the Damudas is at present the following :

Damuda Series (not group)

a. Raniganj—Kamti-group (not Series).

b. Iron Shales.

\* R. G. S. I. IX. 4.

† Amongst plants brought by Dr. Stoliczka in 1871; others sent by Mr. Whitty

‡ R. G. Surv. Ind. IX. 3. p. 84.

§ At any rate, if the flora does not show plainly enough a Triassic age, it indicates at least a mezozoic epoch.

c. Barakur group, with which the

d. Talchir group—is in closest relation.

Thus stands now our knowledge of the relations and conditions of the Damúdas, in which of course our Raniganj coal-field is included.

The flora—the only remainder of former life—of that Damúda series will be worked out as a whole later on. But in the meantime some shorter papers may illustrate certain groups of fossils which are contained in collections other than those of the Geological Museum.

Of such papers the present is the first, and the fossils were collected by Mr. Wood-Mason.

First of all I will give a list of the fossils found by Mr. Wood-Mason, then the descriptions, amongst which I also include short notices of such fossils as occurred in the Raniganj field, but were not found again by Mr. Wood-Mason.

I. LIST OF THE FOSSIL PLANTS BROUGHT BY MR. WOOD-MASON  
FROM THE RANIGANJ COALFIELD.

Palæontological System.	References to Plates.	Living affinities.	Remarks.
I. Equisetacæ.			
Sphenophyllum Trizygia (Royle.) Ung., .....	Pl. XV, 1. 2.	Equisetacæ.	Different from all palæozoic species. Rhizomes? and root- lets.
Vertebraria indica, Royle, ..	Pl. XV, 3. 4. XVI. 4.	Equisetacæ.	
II. Filices.			
1. <i>Sphenopterides</i> .			
Sphenopteris polymorpha, Fstm., .....	Pl. XVI, 5-7. Pl. XVII.		
2. <i>Pecopterides</i> .			
a. Group of Alethopteris Whitbyensis (Schimp. 1869; Fstm. 1876. ....			
Alethopt. Lindleyana, Royle,	Pl. XX. 7.	?	Fructificating speci- men.

Palæontological System.	References to Plates.	Living affinities	Remarks.
Alethopt. cmp. Whitbyensis Göpp., .....	Pl. XXI. 6, 6a.	Pteris ?	In the form of Pteris tenuis, Bgt.
b. Type <i>Phegopteris</i> .			
Alethopt. phegopteroides Fstm., .....	Pl. XVIII.	Phegopteris decussata, Mett.	A new form of fossil ferns.
3 <i>Taeniopteris</i> .			
Macrotaeniopteris danaoides, Royle sp. ....	Pl. XIX. 1, 2. Pl. XXI. 1.	Acrostichum ?	Mezozoic.
Macrotaeniopteris sp. ....			
c. Type <i>Vittaria</i> .			
Gen.— <i>Palæovittaria</i> , nov. gen. 1876.			
Palæovittaria Kurzi, Fstm. ..	Pl. XIX. 3, 4.	Vittaria.	New genus.
4 <i>Dictyopteris</i> .			
Gen.— <i>Belemnopteris</i> , nov. gen. 1876.			
Belemnopteris Wood-Masoniana, Fstm. ....	Pl. XX. 1, 2.	Gymnogrammaesagittata Ettgh. (Hemionitis cordata, Rxbgh. Pteris sagittata, Raddi.	New genus.
Genus <i>Gangamopteris</i> , McCoy, 6.			
Gangamopteris Whittiana, Fstm. ....	Pl. XX. 3, 4.	Antrophyum latifolium, Bl.	New form.
Genus <i>Glossopteris</i> , Bgt. 1828.			
Glossopteris angustifolia, Bgt.	Pl. XXI. 2, 4.	Pteris ? Schizoloma ?	Exhibiting a marginal line.
Glossopt. communis, Fstm. ..	Pl. XXI. 5.	?	
Genus <i>Sagenopteris</i> , Bgt. 1828.			
Sagenopteris polyphylla, Fstm.	P. XX. 5, 6.	?	Glossopteris acaulis McCl.

## II. DESCRIPTIONS OF THE PLANTS FROM THE RANIGANJ FIELD.

The specimens brought by Mr. Wood-Mason represent two orders only : I. *Equisetaceæ* and II. *Filices*.

The specimens are almost all very well preserved in a dark grey shale, and are throughout covered with a very thin film of coal, the former vegetable substance. In this respect they differ from the most of the specimens from Raniganj in the Museum of the Geological Survey, these being mostly in a light grey rock, and only rarely covered with a coal-



film. It seems that Mr. Wood-Mason's plants are from a different clay-band.

In the description of the fossils I will always first discuss those brought by Mr. Wood-Mason, which are mostly figured, briefly mentioning the other plants known from the Raniganj field.

### 1. *EQUISETACEÆ*.

Fossil *Equisetaceæ* are known to occur throughout all the sedimentary rocks from the Devonian unto the present time. But I think this is so with the greatest portion of fossils, and has no consequence as to the possibility or impossibility of determining the age of a certain group. There are always certain differences which enable us to use a fossil organism, although it has some or very close relation in the present world, as a guide in determining the age.

So it is with the *Equisetaceæ* too; each of the formations has its peculiar forms, some of which have more or less perfect representatives in the living *Equisetum*, having a complete spathe in the *articula* of the stalk, while some others have no longer any existing analogues.

As far as I can say the peculiar forms are just in those epochs, where-in the *Equisetaceæ* are most richly developed, as in the palæozoic and mezozoic epoch (here especially in the Trias).

The palæozoic epoch is chiefly characterized by the following :—

- a. *Calamites*, Bgt.
- b. *Asterophyllites*, Bgt.
- c. *Macrostachia*, Schimp.
- d. *Cinyularia*, Weiss.
- e. *Sphenophyllum*, Bgt.\*

The mezozoic is marked by the following peculiar genera :—

- a. *Schizoneura*, Sissimp.
- b. *Phyllothea*, Bgt.
- c. *Sphenophyllum*—a peculiar form.
- d. *Vertebraria*, etc.

The genus *Equisetum* of the fossil Flora agrees, as I have already said, with living forms; and some forms which one takes as *Calamites* are certainly casts, and perhaps sometimes stalks of other *Equisetaceæ*, as well as the lower carboniferous genera *Stigmatocanna*, *Anarthrocanna*, etc., are nothing but forms of *Calamites* with scars disposed in regular arrangement.

\* *Sphenophyllum* has long since ceased to be peculiar to the carboniferous epoch, as we know it from Permian and also from the Triassic Damúdas.

I think some of these *Calamites*-like forms also occur in our Damúdas, but are generally termed *Phyllotheca*.\*

Genus *Sphenophyllum*, Bgt. 1828.

*Plantæ herbaceæ; caule ramoso, ramis alternantibus aut oppositis. Caule primario crassiore, secundariis tenerioribus, interdum tenerrimis, ad articula inflatis, costatis, costis non alternantibus; internodiis in longitudine variantibus.*

FOLIIS CUNEATIS, sessilibus, plurime in articulis verticillatis, interdum alio in modo dispositis; in numero variantibus, numerum duodecim rarius attingentibus; marginibus lateralibus integris, margine exteriori sæpius dentato aut vario in modo inciso.

NERVO MEDIO NULLO, sed nervulis pluribus, æqualibus, ex nonnullis crassiusculis repetito dichotomis. Fructificatio spicaeformis.

This diagnosis, originally drawn up for the *Sphenophyllum* of the palæozoic epoch, I have completed so as to make it applicable also to our Damúda forms.

For in general this genus was formerly considered as characteristic of the true carboniferous formation. But later it was discovered in other portions of the palæozoic epoch also.

Dawson† mentions a *Sphenophyllum* from the Devonian in Canada; I know *Sphenophyllum* from the Culm in Silesia, and another specimen from the Permian, in the so-called Schwarte, in the Rakonitz coalfield in Bohemia and from Stepanitz near Starkenbach (Bohemia), and, finally, from the passage-bed between the Carboniferous and Permian in the so-called "Nürschan-Gasschiefer" from the Pilsen-coalfield in Bohemia‡; so that the genus is now known from all members of the palæozoic epoch. But it is also known from higher beds.

This genus is easily recognised by the shape of the leaves. These are cuneiform, sessile in the articulations of the stalk (therefore in numerous whorls on the stalk), entire on the lateral margin, but may be dentate or incised in various ways on the exterior margin. The veins are also peculiar: there is no midrib, and although the veins are numerous, they

\* In this form the *Phyllotheca* belongs certainly to a great extent to *Schizoneura*, Sch.

† Dawson on the Flora of the Devonian Period in North Eastern America, Q. J. Geol. Soc., Vol. XVIII, pp. 296—330, Pls. XII—XVII; and on the fossil flora of the Devonian and Upper Silurian in Canada. London 1871. 20 Plates.

‡ Feistmantel, Ueber den Nürschaner Gasschiefer, etc. Zeitschr. d. D. geolog. Gesellschaft. 1873.

pass out from the base as two or more main-veins and spread out in the leaf surface repeatedly bifurcating.

The stalk, which as I have mentioned, is articulated, is rarely striated on the surface; the internodes are of different lengths.

As regards the nature of this genus and its relations, it was first described as belonging to the *Marsileaceae*\* by Brongniart; Lindley and Hutton† considered it to be one of those plants which in the ancient world represented the pine tribe of modern floras.

Mr. Unger in 1845‡ also placed *Sphenophyllum* with the *Marsileaceae*, while in 1850§ the same author ranged it with the *Asterophyllites*,|| placing this order, together with the *Equisetaceae* and the *Calamiteae*, in the class *Calamariaceae*; and from that time until Schimper's 'Palæontologie végétale' appeared in 1869 we find *Sphenophyllum* (as a peculiar genus) generally ranged with the *Equisetaceae*.

I think it would be quite unnatural to consider it as belonging to the *Marsileaceae*, as there in the whole world amongst all the *Marsileaceae* is not a single form which has more than one leaf-whorl coming out from the rhizome on a thin stalk, which is never articulated.

Some years ago, however, Mr. Carruthers¶ endeavoured to unite not only *Asterophyllites*, Bgt., with the genus *Calamites*, Bgt., as leaved branches of it, as Mr. Ettingshausen\*\* had already done, but also the genus *Sphenophyllum*, Bgt., although this last is so characteristic.

But quite recently we have some further investigations about this genus by Mr. Williamson†† and by Prof. Renault.‡‡

The latter author would prove that *Sphenophyllum* cannot possibly be an equisetaceous plant, just what Mr. Williamson had attempted to show in the case of *Asterophyllites*; and both these authors would have us believe that *Asterophyllites* and *Sphenophyllum* are very closely allied genera and more closely allied to lycopods than to any other plants. A communication on this subject in the above-mentioned sense I have in a letter of Mr. Williamson (1875).

\* Brongniart, Prodrôme, 1828 p. 68. Royle, l. c. p. 431. XXIX.

† Fossil Flora of Great Britain. Vol. I. 1831-33. pp. 41-44, 86.

‡ Synopsis plant. foss. pp. 112-114.

§ Genera et spec. plant. foss. p. 69 seqq.

Including *Volkmania*, *Huttonia*, *Asterophyllites*, *Annularia*, etc.

¶ The cryptogamic forests, Geolog. Magaz, 1868.

\*\* Haidingers Naturwissenschaftl. Abhandl. 1851. Flora der Steinkohlenformation von Radnitz, Abh. d. K. K. Geol. Reichsanst. 1852.

†† Philosophical Transactions, 1874. p. 41 seqq., Pls. I—IX.

‡‡ Recherches sur l'organisation des *Sphenophyllum* et des *Annularia*, Mém. del Acad. des Science. Paris. 1870.

Already at that time this author supposed that the leaflets of *Sphenophyllum* could have been produced by coalescence of leaves of the genus *Asterophyllites*, just as in *Equisetum* and in *Schizoneura*, wherein the spathes or portions of the spathes are produced by the junction of several leaflets; but in the latter genera we find the spathe traversed by simple veins only, representing the same veins as were in the separate leaflets before these grew together.

In *Asterophyllites* also we have undivided veins in the leaflets. *Sphenophyllum*, however, has repeatedly forked veins: invariably two or more main veins, originating at the base of the leaf, are continually forked until they reach the margin, so that from the two main veins we can have as many as 20—30 forked veins reaching to the margin in one leaflet.

But that which Mr. Williamson three years ago advanced as a supposition only he brought forward as an established fact before the last meeting of the British Association at Glasgow,\* saying that the wedge-shaped leaves of *Sphenophyllum* are merely the result of the coalescence of several of the leaves of *Asterophyllites*.

The learned author, who at that meeting expressed also his “strong conviction† that the flora of the coal-measures would ultimately become the battle-field on which the question of evolution with reference to the origin of species would be fought out,” will certainly excuse me, taking especially our Indian *Sphenophyllum* into consideration, for entertaining some doubts as to the close relationship of *Sphenophyllum* and *Asterophyllites* in the above-mentioned sense.

As our figure (Pl. XV, Fig. 2a) plainly shows, the veins of our *Sphenophyllum* pass out as two main veins and are forked in a regular way until they reach the margin. Here no coalescence of leaflets is possible, least of all of *Asterophyllites* where the leaflets have only one undivided midrib.

Further, everybody knows very well that the leaflets of *Asterophyllites* are linear and attenuated both towards the base and towards the apex, so that they could never produce by their coalescence a wedge-shaped leaf, with the broadest portion just at the apex as in *Sphenophyllum*.

Our *Sphenophyllum* shows this further to be quite impossible by the arrangement of the leaf-whorls in the *articula*, as we always find quite regularly three pairs of leaflets, of which one pair is smaller than the others.

The stalk also is generally thinner in the genus *Sphenophyllum*, our Indian form showing this very evidently.

If the leaflets of *Asterophyllites* were to grow together, they would

\* I have read the report published in *Nature* for 21st September, 1876, No. 360, p. 455, the only one which has as yet reached us.

† *Ibidem*, p. 456.



form either a dentate upright spathe or an oblong-oval leaf, which, however, would also be upright in the manner seen in *Equisetum* and *Schizoneura*. In the latter genus there are generally two spathe-portions, which are oblong-oval and contain as many distinct simple veins as leaflets have grown together; in some cases we see the leaflets separated again by dehiscence, but they could never produce anything like the leaf of *Sphenophyllum*, in which also the forked veins afford a chief difference.

I am much inclined to believe that both genera have the same microscopical structure and belong to the same order; but I think it is against all morphological and biological laws to suppose that linear leaflets, which are attenuated at both ends and all contain invariably only one undivided rib, could ever by their coalescence produce a wedge-shaped leaf, with a narrow base and a disproportionally broader apex, and with 2 or 3 chief veins, which are repeatedly forked to the margin.

All these relations, together with the much thinner stalks and a different fruit-spike, will, as I think, still maintain *Sphenophyllum* as a peculiar genus belonging, with *Asterophyllites*, to the same order; but that this is that of the *Lycopodiaceae*, must, as I think, be thoroughly proved\* before one can draw any conclusions.

But for the present I think it is better to leave them both in the class *Equisetaceae*, when following Schimper's system, we have :—

Class :—EQUISETACEAE.†

Order I.—EQUISETACEAE, true horsetails.

*Equisetum*, Linn.‡

*Schizoneura*, Schmp.§

*Equisetides*, Schmp.

*Phyllothea*, Bgt.||

Order II.—CALAMARIEAE.

*Calamites*, Suits.

*Asterophyllites*, Bgt.¶

Fruit-spikes.

*Sphenophyllum*, Bgt.

*Annularia*, Bgt.

Schimper does not mention the *Sphenophyllum* from our Damúdas at all; and his diagnosis, therefore, as referring only to the palæozoic

\* While this paper is passing through the press, I have heard that Mr. Stur of Vienna proves that *Sphenophyllum* cannot by any possibility be a Lycopod.

† The Indian forms are spaced.

‡ None in Damudas; one species in the Rajmahal Hills.

§ Very abundant in the Raniganj group and in Trias in Europe.

|| Very frequent also in Italian Oolite.

¶ Schimper uses *Calamocladus*, Schimp.

species, is not quite complete ; and hence it is that he speaks only of forms with complete leaf-whorls in which all the leaflets are equal.

But from my more complete diagnosis is seen that there can be distinguished two groups as regards the arrangement of the leaves.

1. *With complete whorls.*

This group would include the palæozoic forms.

2. *With incomplete whorls.*

In this I place the Triassic forms of our Damúdas. A case analogous to this we will find in *Neuropteris*, Bgt., wherein the bi- and tri-pinnate fronds belong to the palæozoic epoch, while the single-pinnate forms occur in the Trias.

*SPHENOPHYLLUM TRIZYGIA*, Ung., Pl. XV, Figs. 1, 2, 2a.

1839. *Trizygia speciosa*, Royle, l. c. p. XXIX. p. 431, Pl. 2. f. 8.

1845. ———, Unger Synopsis. plant. foss. p. 114.

1850. *Sphenoph. speciosum*, McClell., Report, p. 54. Pl. XIV. f. 5.

1850. *Sphenoph. trizygia*, Ung., Gen. et. sp. pl. f. pag. 71.

1860. *Sphenophyllum*, T. Oldham, M. G. Surv. II. p. 316.

1865. *Trizygia*, W. T. Blanford, Raniganj coal field M. G. S. Ind. III. p. 31.

1876. *Sphenoph. Trizygia*, Feistmantel, Notes etc., Rec. G. S. I. IX. 3. p. 70.

*Caule articulato, tenerrimo, fluctuante (?) ; foliis senis in articulis, totum verticillum haud formantibus, sed unilateraliter in tria paria dispositis ; pare summo longissimo, imo brevissimo minimoque, medio medio-cris. Foliis obovato-oblonge cuneiformibus ; NERVO MEDIO NULLO, nervulis crebris aequalibus EX DUOBUS primariis regulariter dichotomis.*

Stalk articulate, very slender, floating (?) ; the leaves by six in each articulation, not forming a complete whorl, but disposed on one side of the articulum in three pairs ; the uppermost pair the longest, the lowermost the smallest ; the leaflets oblong-cuneiform, ; no midrib, but the veins numerous, equal, regularly dichotomous out of two chief veins.

Of this interesting species Mr. Wood-Mason has brought several nice specimens, of which I figure two, to show the different sizes, the lower leaflets being much longer than the upper ones.

The collections of the Geological Survey contain also a great many specimens of this species ; and other figures will be given in the 'Palæontologia Indica'.

This species was first discovered by Mr. Royle and figured and mentioned as *Trizygia speciosa* ; with this name we find it still in Unger's Synopsis (1845) and in the Mem. G. S. India. But McClelland in 1850 and Unger also in 1850 placed it with *Sphenophyllum*, Bgt., the former keeping the older specific name, *speciosum* ; the latter substituting *trizygia*

for it, which I adopt too, as it shows that the species belongs to the genus *Sphenophyllum* and has the leaves in three pairs (*trizygia*), while it at the same time recalls Royle's generic name.

That the fossil under discussion belongs to *Sphenophyllum* cannot, I think, be doubted, as all the characters of the stalk and of the leaves agree well.

But it has a very characteristic peculiarity in the leaves, which is constant in all specimens hitherto found: it is that there are in all specimens only six leaflets in each *articulum*, forming three pairs of different lengths and sizes, arranged on one side of the articulation. The leaflets are entire; the veins are very numerous in the broad portion of the leaflets; they begin as two main veins, which are forked at almost equal distances dichotomously, until one can count 18—20 at the apical margin; some of them, especially those on the lateral margins, are continued undivided after the second or third furcation.

By this condition of the leaves, our species differs totally from all palæozoic forms, and is not at all opposed to the view of a mezozoic age for the Raniganj group; and thus the division of this genus into two groups is quite justifiable.

But there is another circumstance which renders this fossil important.

It was formerly known only from Raniganj, and McClelland's specimens came from that locality. But later it occurred also at Talchir (Cuttack) in Orissa, in a dark sphærosideritic shale. These beds near Talchir and Cuttack had hitherto been ranged with the lower portion of the Damúdas or the Barakúr group.

The specimens from the Raniganj and Barakur group represent the same species, only in the latter they are generally of slightly smaller size.

We have, therefore, in *Sphenophyllum trizygia* already one typical species which is common to the upper and to the lower portions of the Damúdas.

Lately Mr. Schenk\* described a form from the Wealden as *Marsilidium speciosum*; but if I see aright, this form also exhibits two whorls of leaves in the articulations of the stalk, and it would have been more natural to have ranged it with *Sphenophyllum*, as it is well known that no known *Marsileaceae* have more than one whorl of leaves.

Besides the *Sphenophyllum trizygia*, Ung. there are known from the Raniganj coalfield other important forms belonging to the *Equisetaceae*, which I cannot omit to mention, but of which I give only a few figures,

\* Fossile Flora der Wealdenformation; Palæontographica, Cassel, 1871, p. 225. Pl. XXVI, Fig. 3.

because no representatives of them are amongst Mr. Wood-Mason's specimens, and because those from our collection will be hereafter figured sufficiently in the 'Palæontologia Indica.'

Genus **Schizoneura**, Schimp. 1844.

This very peculiar genus was established by Mr. Schimper\*. It was formerly known only from the Trias, of which formation it is especially characteristic; Schimper† having only recently placed the Rhætic *Calamites Hoerensis*, Hss.‡ in this genus as *Schizoneura Hörensis*, Schimp.; so that this author can well say (l. c., p. 282), "*Le genre Schizoneura caractérise le Trias et les couches Rhétique.*"

The species of *Schizoneura* known at present are:—

*Schizoneura paradoxa*, Schimp. (l. c.), from the Upper Grés Bigarré (Lower Trias) in the Vosges.

*Schizoneura Meriani*, Schimp., from the Keuper near Stuttgart, Salz-sur-le-Necker, etc.

*Schizoneura Hoerensis*, Schimp., from the Rhætic at Hoer in Scania, Salzgitter in Hanover, etc.

This genus is a very characteristic one. It has an articulated stalk or stem; the originally separate leaflets are grown together into a spathe, which, however, attains a much greater length than the internodes and consequently bursts generally into two pretty equal portions, each containing as many pretty thick ribs as there are leaflets grown together. Owing to the original form of the leaflets (narrower at base and towards the apex), these two portions have an oblong oval shape and are always directed upwards. Sometimes the dehiscence goes further still, so that we find one portion of the spathe only entire and the other split into several leaflets, or even both portions are resolved into leaflets.

In our Raniganj group this genus is very abundantly represented, especially at Raniganj, specimens from which locality have been for many years (16) in the collections of the Geological Survey. But up to date neither figures nor descriptions of it have been published.

It is simply mentioned as *Schizoneura* in the Mem. G. S. India. Lately§ I examined the specimens and found the species identical with that in the Panchet group. I established it therefore as follows:—

\* Schimper et Mougeot, Monogr. d. plant. foss. du grés bigarré 1844, pp. 48—51, Tab. XXIV—XXVI.

† Pal. végét. I, p. 283.

‡ Hiesinger, Lethea Succ. Supp. II, p. 5, Tab. XXXVIII, Fig. 8.

§ Rec. G. S. Ind. IX, 3, p. 69.



## SCHIZONEURA GONDWANENSIS,\* Fstm., Pl. XVI, Figs. 1—3.

1876. Feistmantel, Rec. Geolog. Surv. Ind. IX, 3, p. 69.

*Trunco articulato ramoso, caule† articulato, striato, variabili altitudine ac latitudine, foliolis 12—22, plerumque duas in partes vaginae coalitis, nonnunquam etiam liberis suberectis; foliis (partibus vaginae) oblonge ovalibus, usque ad 14·5 cm. longis et media in parte 2·5 cm. latis; 7—11 nervos (singulorum foliorum) continentibus.*

On this species I will here make only a few short remarks, as full details will be given later on.

a. It is very closely allied to *Schizoneura paradoxa*, Sch. M.,‡ the only difference being that our species has the portions of the vagina broader and has therefore more veins (indicating the leaflets which by their coalescence have formed the vagina).

b. As in *Schizoneura paradoxa* the portions of the spathe are sometimes found burst into the original leaflets: and thus we find it in our Raniganj species, but more frequently with only the apex of the spathe split as indication to further bursting; in our figures two leaflets (figs. 1 and 2.) exhibit this state, and on a future occasion I will illustrate this further.

c. *Schizoneura paradoxa* is a typically Triassic fossil. We may, therefore, consider our species also as Triassic.

d. The Damuda species is not different from that in the Panchet group, which latter I have also designated *Schizon. Gondwanensis*.§

e. It occurs, therefore, in both members of the lower portion of the Gondwana system, and from this circumstance I derived the specific name.

f. No *Schizoneura* is as yet known from Australia|| with certainty, and to consider the genus *Zeugophyllites*, Bgt.,¶ as *Schizoneura*, as Messrs. T. Oldham\*\* and H. F. Blanford†† have done, would be merely a supposition, as every one must recognise at once and that very easily the great difference between these two fossils. It is also incorrect to consider, as Mr. W. T. Blanford‡‡ has done, the Australian *Nöggerathia* as ? *Schizoneura*, the two latter genera being quite as distinct as the two

\* I give here only 3 little figures as all the other specimens will be figured in the Flora of the Damuda Series in the *Palaeontologia Indica*.

† *Foliifero*.

‡ L. c. pp. 50, 51. Pls. XXIV—XXVI.

§ R. G. S. Ind. IX. 3. p. 66.

|| I mean from the lower coal-measures, in which marine fossils predominate.

¶ Prodrôme 1828, pp. 118-121; Streleccki, Phys. Descript of New South-Wales,

1845.

\*\* M. Geol. S. Ind. II, p. 327.

†† Q. J. G. Soc. 1875, p. 527.

‡‡ Rec. G. S. Ind. IX, 3.

former are from one another; and I think certainly that Mr. W. B. Clarke would be able to distinguish a *Nöggerathia* from a *Schizoneura* or *vice versa*.\*

My opinion about the Australian *Zeugophyllites* is that it is rather a *Zamieae*, as it differs in its chief characters from *Schizoneura*.

This latter has, owing to the coalescence of the leaflets into a common spathe, or after the dehiscence of the one spathe into two portions, much thicker veins, the representatives of the midribs of the originally separate leaflets, and the veins are also much more distant and all of equal thickness, while *Zeugophyllites*† has many more veins, which are the venation of the leaf itself, this being plainly rather a single leaf than the result of the coalescence of several leaflets.‡

I would consider it as belonging to the genus *Zamites*, Bgt., or perhaps also to some of the *Podozamites*; these genera are all meozoic.

In a paper by Mr. Bronn on the Triassic flora of the Raibler Schiefer,§ on pl. vii. fig. 4, is figured a specimen which is tolerably like the Australian *Zeugophyllites*, only that the veins are a little thicker.

*Schizoneura* and *Zeugophyllites* are therefore substantially quite different, the latter being a single leaf, the former having leaves formed by coalescence of several leaflets.||

*Schizoneura* is especially known from the Raniganj field, Jheria coalfield, but almost in the same abundance also from the Nerbudda valley (upper Denwa valley near Barkundum). In the flora of the Damúda group many specimens of this genus will be figured.

#### Genus *Phyllotheca*, Bgt. 1828.

1828, Brongniart Prodrôme, 1828, p. 151.

The systematic position of this genus is, as I think, in the *Equisetaceae*, as the leaf-spathe plainly indicates. I do not see anything uncertain about it.

The most characteristic forms of this genus are known from the Italian Oolite.

\* From specimens which I have seen from Australia I have satisfied myself that the Australian *Nöggerathia* is certainly a *Nöggerathia* in the same sense as *Nögg. Histopi*, Bunb. Schimper considers *Zeugophyllites* to be a *Cycadeaceae*.

† In my note on the Damuda Flora, R. G. S. India, IX. 3, p. 69, 4 lines from below, after the words "seem to belong also to *Schizoneura*" the words "according to Mr. Oldham" have been omitted, as can be seen from the following sentence, wherein I plainly say "that I do not know anything like *Schizoneura* from the lower coal-strata in Australia."

‡ Streleciski, l. c. p. 250, Pl. VI, f. 5.

§ N. Jahrb. f. Min. etc. 1858.

|| Dana (U. S. Explor. Exped., Geology, p. 715) refers *Zeugophyllites* to *Nöggerathia*.

The first specimen was described by Ad. Brongniart,\* from Australia; it was the *Phyllothea australis*, Bgt.; later, Mr. McCoy added the *Phylloth. ramosa* and *Ph. Hookeri*,† which, however, seem not to be different. Subsequently Sir Ch. Bunbury described the *Phylloth. indica* from the Nagpur District,‡ and later still Mr. de Zigno§ described complete specimens from Italian Oolite.

No forms like these are known from true coal-measures anywhere.

This genus has, therefore, its analogues as well in the upper Australian coal-measures as in the Italian Oolite.

The Australian *Phyllothea* resembles the Italian forms most wonderfully.

From India the real *Phyllothea indica*, Bunb., was formerly only known from the Kamthi group|| (Nagpur district).

But only lately I succeeded in discovering a specimen of *Phyllothea*, Bgt., in the real sense in our Raniganj collection; it is identical with the Kamthi species, and is further evidence that both these groups belong to the same horizon.

Although our *Phyllothea* at first sight seem very near some from Australia, they are yet distinct from them in the mode of formation of the leaf-spathe in the *articula*; our specimens having generally much thinner, and therefore more numerous leaflets, which are not grown together into so long a tube (spathe) as in some of the Australian specimens, the leaflets of which are generally broader: in which respect they agree more with those from Italy: the spathe is also longer.

#### INCERTÆ SEDIS.

Genus *Vertebraria*, Royle, 1839.

Pl. XV, Fig. 3, and Pl. XVI, Fig. 4.

Amongst Mr. Wood-Mason's specimens is also numerously represented that form which is so common throughout the whole Damúda Series, and which was first called by Royle *Vertebraria*, but the true nature of which has not been satisfactorily made out to date.

Dr. Royle¶ mentions this fossil only, without any description. He distinguished two species, which I do not consider to be different. The one called *Vertebr. indica* is the more common type.

\* Prodrôme 1828, pp. 175, 152.

† A. and M. N. H. 1847, pp. 155-157.

‡ Q. J. G. Soc. XVII. p. 355, Pls. X. XI.

§ Flor. form. Oolith. 1856—1868. (Only these fascicles are in my hands.)

|| Most of the other specimens which are mentioned from elsewhere as *Phyllothea*, especially from the Raniganj field, and which represent mostly stalks and stems, belong, as I think, to the genus *Schizoneura*, Schimp., as stem portions, the real *Phyllothea*, Bgt., being rather rare.

¶ Illustr. Bot. etc. Him. Mount. 1839, p. 29. Pl. II. 1. 2. 3. 4. 5.

The first discussion of this genus we find in McCoy's paper on the fossil botany and zoology, &c. of Australia,\* wherein the author especially describes *Vertebr. Australis*, McCoy, which is something like Royle's *Vertebraria radiata* from India. But as both species were founded on very insufficient materials, and as the figure in McCoy's paper is the only existing one, it would be rather hazardous to draw any conclusions; and yet generally the Australian *Vertebraria* has both by Mr. Oldham and by Mr. W. T. Blanford been taken as identical with our Indian one.†

McCoy considered his specimen to be very near to the genus *Sphenophyllum* as a form with very short internodia, so that the leaf-whorls are very approximate. It is true that it looks at first sight a little like it, but I think it to be altogether an accidental preservation of the common form.

From this consideration Mr. Unger quoted the forms of *Vertebraria* as *Sphenophyllum*; and from this consideration of McCoy and determination of Unger I think it has happened that there is mentioned from Australia also the genus *Sphenophyllum*, no specimens of which have ever been described or figured from that country.

The next discussion of *Vertebraria* is to be found in Bunbury's paper on the fossil flora of Nagpúr,‡ wherein the author speaks especially of his figure 1. c., Pl. XI. 3, of which he plainly says that it cannot be either *Sphenophyllum* or any one of the *Asterophyllitaceae*, but that it appears to him rather to be the roots of some large plants, and so he concludes—

“On the whole, then, I am of opinion that the branched specimens from Kamthi, which have been taken for *Vertebraria* were the roots of some plants, possibly of *Phyllothea*,§ Bgt., that they had probably a woody central axis of small diameter, that between this axis and the outer coat or rind there was a hollow, traversed at irregular distances by incomplete partitions, which connected the outer coat with the axis.

“The unbranched specimens were most likely also fragments of root, though it is not quite so clear.” This is the extent of our knowledge of this peculiar genus.

I think I will presently be able to make some further remarks about this genus, especially about the unbranched form. Such specimens are well represented in Mr. Wood-Mason's collection; they are mostly pretty large, but some of them are branched too, but in a way other than in the specimen discussed by Sir Charles Bunbury.

\* A. and M. N. H. Vol. 20, 1847, pp. 145-147.

† I have a good, pretty large specimen of *Vertebraria* from Australia (Bowenfels upper coal-measures) before me which is totally different from our forms. As yet *Vertebraria* is quoted only from the upper coal-strata.

‡ Q. J. G. Soc. XVII, p. 338.

§ In Nagpúr it is very likely so, as there *Phyllothea* (in the true sense) occurs plentifully, while in the Raniganj field it can belong to another genus.



The most instructive specimen is that which I have figured (pl. xv, fig. 3.), and it will be sufficient first to discuss this.

It represents a thickish stem with a branch passing out of it.

The stem appears at first sight to be of the same kind as Royle's\* *Vertebraria indica*, but our specimen has the "middle axis," if one can so call it, broader. The whole stem shows the seemingly irregularly disposed 'breakings' on both sides of the axis, but a closer inspection shows that they are not so irregular.

The only difficulty of observation is that the specimens are generally very much crushed and have the outer coat destroyed, but the one under discussion is better preserved than most others.

The most important point about this specimen is that the whole surface is regularly longitudinally ribbed, in the same manner as the fossil *Calamites* or *Equisetum*; the ribs are rather broad, on the average about 2 mm., and are separated by thick lines (or very thin ribs, as one may call them), in the same way as is seen in some *Calamites* of the coal-measures.

The ribs are in general continuous over a long portion of the stem, but on some of the 'breakings' there are apparently interruptions of the ribs; the ribs ending regularly in the 'breaking' and the next ribs beginning again independently.

This reminds one very closely of the formation of an articulation in a *Calamites* or, indeed, in the *Equisetaceae* in general, and I consider it as representing an articulation. Our figure (pl. xv, fig. 3, *a. a. a.*) exhibits these relations very well.

So far they would agree completely with *Calamites* or *Equisetum*, and as regards the breadth of the ribs, mostly with some of the Triassic forms.

In these articulations the ribs do not alternate, as they generally do in the carboniferous *Calamites*,† but are arranged as they almost always are in the Triassic forms.

From what I have said about this stem, I am quite certain that it belongs to the *Equisetaceae* or at least to some order in which the *Calamites* must be placed; which is shown by the ribbed surface and by the articulations. But how to explain the 'breakings' of the stems? They are not so irregular as they seem to be at first sight. One thing is certain, that the articulations which I have observed on our specimen are just in the 'breakings'; perhaps this genus was very fragile at the articulations; but Sir Charles Bunbury's hypothesis could be right too.

Yet another circumstance must be mentioned, which is of importance and could partly explain the 'breakings'. Our specimen is also branched;

\* l. c. Pl. 2. f. 1.

† In the true Carboniferous I know of only one instance where the ribs do not alternate; it is in the coal formation of Silesia.

but the branch does not grow out from the body of the stem, being inserted in an articulation, or at least in a 'breaking', and being joined to the main stem by an articulating surface (pl. xv, fig. 3, b.) in the same way as in *Calamites*, and in the *Equiseta*, fossil and living. The branch shows the same structure as the main stem, a central axis (?), the 'breakings,' and the striation of the surface.

I suppose this insertion of branches by a special articulation could produce in a certain way of preservation foldings or breakings similar to those seen in this specimen.

But still something must be considered. It is known that the rhizomes in living *Equiseta* are constructed in nearly the same way as the stems above the surface, but that, when they dry, they contract and shrink in different degrees. Our specimen could very easily represent such a state of things.

Another specimen of importance is that figured on pl. xvi, fig. 4.

It is a thin, compressed stem, which is preserved with the surface, as no axis is visible, but the characteristic 'breakings' and contractions are pretty well marked, so that nobody can deny its being a true *Vertebraria*, Royle; but what is interesting in this specimen is, that the 'breakings' and contractions are quite regular, corresponding with the articula and internodes of equisetaceous plants. One can count 9 internodes and therefore 8 articula, which are pretty much of the same length. The articula are well marked by a constriction and a 'breaking' in both adjoining internodes.

The surface is smooth, but on the right side (of the figure) of the original specimen are seen in all the internodes several ribs, which seem to be interrupted in the place of the constriction, and thus to form an articulation similar to that which I have already described in the other specimen.

I can therefore draw, as regards the specimens before me, the following conclusions:

1. *Vertebraria* was most probably the rhizome of a certain equisetaceous plant.

2. This is rendered probable by its very frequent occurrence throughout all the strata of the Damuda series in an almost unaltered appearance—further by the regular striation or ribbing of the surface and the partially preserved articulation.

3. Some of the "breakings" may have been produced by the insertion of branches in the articulations.

4. What now about the relations? there we are obliged to suppose that they belonged to some frequent plants. Here in Raniganj it is very easy to find the connection, where other equisetaceous plants are so frequent, especially *Schizoneura*, Schimp, to which most of the stems known here as *Phyllothea* belong, as I think, as stalks above the surface.

We should therefore have *Vertebraria* as rhizome, *Phyllothea*\* (those stems which are called by this name) as stalks, and *Schizoneura* as the leaved branches of one and the same plant.

5. But I think *Vertebraria* could have belonged as rhizome also to some other plants of other genera or species, and in the Raniganj field it could have belonged also to *Sphenophyllum*, in the Kamthis to the *Phyllothea indica* (the real *Phyllothea*).

6. In Australia, in the upper coal-strata, this genus belonged certainly to *Phyllothea* too, as it is always associated with it, and no other Equisetaceous plant has hitherto been found with it.

7. But in some localities we do not find it associated with any plant to which it could be referred; which, however, is no proof against the suppositions I have just made.

Besides these complete specimens of *Vertebraria*, a specimen is in Mr. Wood-Mason's collection which more resembles that described by Sir Charles Bunbury: it is a branching specimen, which in reality seems to be a rootlet, as Sir Ch. Bunbury explained it; I have given a figure of it on pl. xv, fig. 4.

From other places we have better specimens of the same kind, in which the branching agrees exactly with Sir Charles Bunbury's description; and I will describe them hereafter.

The following table is given to illustrate the occurrence of Equisetaceæ in the Raniganj field:—

\* The real *Phyllothea* with a closed leaf-spathe is a peculiar genus.

## III. GENERAL VIEW OF THE Equisetaceæ IN THE RANIGANJ FIELD.

Names of the Species from Raniganj field.	Where in other portions of the Damu- das.	Europe.		Australia.
		Trias.	Jura.	
Class Equisetaceæ.				
Order I. <i>Equisetææ</i> .				
Schizoneura Gondwanensis, Fstm.	Jherria coal- field. Danwa val- ley. Very frequent also in the Panchet group.	Genus : lower Trias in the Vosges. Keuper at Stuttgart		
Phyllothea indica, Bunb....	Kamthi Beds (Nagpur dis- trict.)	....	Genus (real) : Italy.	Genus in the up- per coal-beds in New South- Wales; the same species also in Victo- ria, here with <i>Tueniopteris</i> <i>Daintreei</i> , Mc- Coy, which in Queensland is characteristic of the meozoic formation.
Vertebraria indica, Royle....	In all por- tions.	....	....	Genus in Aus- tralia.
Order II. <i>Calamariææ</i> .				
Sphenophyllum trizygia, Ung.	In the Bará- kár group at Talchir in Orissa.	....	....	From Australia I have never seen a figure or any description.

## II. FILICES.

The remains of ferns in the Damudas in general, and in the Raniganj beds in particular, were up to this time no rarity, on the contrary they occurred pretty frequently as regards specimens, but as regards variety of forms they must be considered to have been very poorly represented.



For only the genus *Glossopteris* occurred at all frequently, and this was the only fern formerly regarded as of any importance, because the other forms were of rarer occurrence.

But now we know that even amongst the older collections were other forms of importance, to which last year two others were added from Kurhurbali; and this year Mr. Wood-Mason has added a good number of interesting forms, all of which bear a mezozoic habitus, *Taeniopteris*-like forms and ferns with net-venation predominating.

The studies and works of the most illustrious palæontologists have shewn that the floras of the different epochs have in general special and distinctive characters, although these may not be so strictly limited as in the faunas, and although transitional forms are very often met with.

Thus we know that the coal-period in Europe and America, and the real lower coal-measures in Australia (Port Steffens, Smith's Creek, etc.), have their own flora, which is characterized by certain *Equisetaceæ*, and amongst ferns especially by the *Sphenopterides*, true *Neuropterides*, prevalent *Alethopterides*, *Lepidodendron*, *Cyclostigma*, *Sigillaria*, *Stigmaria*, etc. Forms with net-venation are rare, the true *Dictyopteris* and *Lonchopteris* being nearly the only forms of this kind and *Taeniopteris* being rare.

The mezozoic epoch, however, is especially marked by these forms with net-venation—forms generally different from the genera mentioned above from the true carboniferous: we find *Sagenopteris*, *Cheiropteris*, *Clathropteris*, *Camptopteris*, *Gangamopteris*; more numerous *Cycadeaceæ*; frequently the order *Taeniopterides*, of different types; amongst the *Pecopterides* we find certain forms, of which many can be united into one group, of which *Alethopteris Whitbyensis*, Göpp., may be taken as the chief representative; and we find on the whole more numerous forms allied to living genera.

This, however, does not exclude the possibility of a genus like *Glossopteris* having existed in Australia at a time when carboniferous marine animals lived.

The ferns which Mr. Wood-Mason has brought are for the most part of such a nature that one can point with probability to their living allies.

I will not here speak more in detail of the ferns, as I have entered fully into the subject in my Kach and Rajmahal flora in the 'Palæontologia Indica,' and will only indicate the palæontological order of ferns, in which I will discuss them; the best and latest system is to be found in Schimper's 'Palæontologie végétale' and is as follows:—

Order I.—*Sphenopterides*.

„ II.—*Neuropterides*.

„ III.—*Pecopterides*.

„ IV.—*Taeniopterides*.

„ V.—*Dictyopterides*.

Genera adhuc viventia, etc.

Of these last I mention here only the order *Gleicheniaceae*, which is represented in the Rajmahal Hills.

Of these orders, I, III, IV, and V, are represented frequently enough amongst our Raniganj fossils, if we consider that the mezozoic epoch as a whole, especially the Trias, was rather poor in ferns, much poorer than the palæozoic epoch; we see, in Europe, that in the Trias, in comparison with the Permian and Carboniferous rocks, the forms are rather rarely represented. And so it is in India; and I think this circumstance, that is to say, the poverty in variety of forms, together with the very frequent occurrence of the genus *Schizoneura* and such characteristic fossils as a single pinnate *Neuropteris* (which is a Triassic type), the genus *Voltzia* with 2 species, *Albertia*, etc., can be used with far greater effect to bring our Damuda flora into contrast with the palæozoic flora, than the rarity of Cycads can to indicate a break between the lower and upper portion of the Gondwana system, both of which are closely allied by the mezozoic habitus of the flora in general.

In Australia the lower coal-measures with prevailing carboniferous marine animals must be taken as of that age, although some plants occur, which become more developed in the upper coal-measures, where only a flora is found which is not contrary to the supposition of a mezozoic age, although it cannot be well compared with our Damuda flora.

When I said that orders I, III, IV, and V, are especially represented amongst our ferns, I should have explained that these are only palæontological orders, which, however, are as well founded on certain characters as the living ones.

Botanists, it is well known, use the fructification, besides the venation, as a chief character in establishing their orders and genera. The former, however, being rarely found in fossil plants, the palæobotanist is obliged to use other constant characters, of which the venation and the shape of the leaf stand in the first place, and hence it is that in the same fossil genus (for instance, *Pecopteris*), we may find represented several living genera, which, however, cannot always be recognised, as only in a minority of specimens is the fructification preserved, while the typical venation of the genus *Pecopteris* will always be found indicated. The same we find amongst the *Tueniopterides*, *Dictyopterides*, etc.

Mr. Ettingshausen\* published in 1865 a valuable work on living ferns, which is written for the special purpose of showing to what living types fossil ferns can be referred or which living forms are analogues of the fossil ones. In the present paper I shall have occasion to refer several times to this work.

\* Die Farrenkräuter der Jetztwelt etc. nach dem Flächenskelet bearbeitet; Wien 1865.

## Order SPHENOPTERIDES (æ.)

This order is especially developed in the carboniferous epoch, where we find forms with leaflets and fronds of the most different shapes.

The following genera have been distinguished—

*Sphenopteris*, Bgt.

*Hymenophyllites*, Bgt.

*Trichomanites*, Bgt.

*Schizopteris*, Bgt.

But there is no great difference between *Hymenophyllites* and *Trichomanites*, and we already find in Mr. Geinitz's 'Steinkohlen Deutschlands' some *Trichomanites* ranged with *Hymenophyllites*, also *Schizopteris* placed with the *Sphenopterides*. With this I perfectly agree, as I will show further on.

D. Stur (in Vienna) for a long time considered *Schizopteris* as belonging to the *Neuropterideae*.

The *Sphenopterides* have as their analogues in the existing flora the genera *Gymnogramme*, *Notochlaena*, *Cheilanthes*, *Davallia*, *Dicksonia*, *Aneimia*, etc.

Schimper, in his 'Palæont. végét.', used these living affinities to form as many subgroups of *Sphenopteris* as there are names of living genera analogous to it, as follows:—

*Sphenopteris Gymnogrammides*.

*Sphenopteris Notochlaenides*.

*Sphenopteris Cheilanthides*.

*Sphenopteris Davallioides*, etc.

Everybody will acknowledge this to be very reasonable, but it has only this one fault, that one is not always able to distinguish all the characters by which a species should be ranged with a particular subgenus.

Schimper distinguishes also a *Sphenopteris Trichomanides* and *Hymenophyllides*, which, however, are not far from each other, and which are better ranged with *Hymenophyllites*, Göpp.

For *Schizopteris* he establishes a new genus *Rhacophyllum*, as also separates some types formerly referred to *Sphenopteris* and places them in a new genus *Rhacopteris*, Schimp.

But some of these are certainly *Sphenopteris*, although Mr. Stur in a recent paper\* again uses this name and places it with the *Ophioglosseae*. I, however, think it is much better to keep them with *Sphenopteris* too, and, following Mr. Schimper, to make a special subgroup of *Sphenopteris*, as they show a great affinity with this fossil genus and one otherwise would consequently have to place all the others in the living families also.

\* Culmflora des Mährisch-Schlesischen Dachschiefers, Abh. der K. K. Geol. Reichsanstalt in Wien, 1875.

These have nothing to do with the *Ophioglosseae*; I would mention only the two carboniferous\* species, *Rhacopteris Asplenites* and *Rhacopteris Rikonitzensis*, Stur; the former is a real *Sphenopteris*, the other is certainly a *Zamiaceae* belonging to the genus *Nöggerathia* and has already been described as *Nöggerathia intermedia*, K. Fstm.

Some of those, however, which are placed in *Rhacopteris* with the other types of *Sphenopteris* are indeed different, and they should never be placed with them; they may have their affinities in the *Ophioglosseae*, as I will show especially on some specimens from Australia from the real lower coal-measures which certainly resemble *Botrychium* in the shape of the leaves.

From the Raniganj coal-field no *Sphenopteris*† has as yet been described, and I have not met with any specimen with certainty. Amongst Wood-Mason's specimens, however, are several, which on a closer examination turn out to belong to this genus.

#### Genus *Sphenopteris*, Bgt. 1828.

- 1828. Brongniart, Hist. d. végét. foss.
- 1841. Göppert, Gatt. foss. Pfl. I. p. 67.
- 1850. Unger, Gen. et Spec. plant. foss.
- 1855. Genitz, Verst. der. Sächs. Steinkohlenf.
- 1869. Schimper, Pal. végét. I.
- 1873. Feistmantel, Zeitsch. d. D. g. Gesell. 502. seqq.
- 1876. Feistmantel, Rajm. Flora. in Pal. Indica.

*SPHENOPTERIS* POLYMORPHA, n. sp., Pls. XVI, Figs. 5—7 & XVII.

*Fronde tripinnata; rhachide primaria et secundaria late alata; pinnis alternantibus, sub angulo subrecto e rhachide primaria egredientibus; tota in fronde differentibus; superioribus semel pinnatis, pinnulis solum paulo sinuatis aut lobatis, alternantibus‡; mediis longioribus, etiam semel pinnatis, aut pinnulis distincte lobato-incisis; imis longissimis distincte bipinnatis, § pinnulis pinnatis, longioribus; pinnulis earum pinnularum denticulatis; nervis pinnularum primariis e rhachide pinnarum egredientibus, nervos secundarios in lobos aut pinnulas (secundi ordinis) emittentibus, furcatis.*

There are several specimens, which gave me the idea of this form.

One specimen especially, portions of which are figured on pl. xvi, figs. 5—7 shows the characters of this form plainly.

\* From coal-measures in Bohemia.

† Mr. Oldham, Mem. Geol. Surv. Ind. II., p. 32, mentions, it is true, the genus *Sphenopteris*, but no species is named and no discussion nor any precise locality is given.

‡ So they are throughout.

§ Tota frons hoc modo tripinnata.



The upper portion of the frond (pl. xvi, fig. 5.) is only bipinnate, the pinnæ have pinnulæ which are only a little lobed; in the middle portion the pinnulæ are longer and more deeply lobed, and we can call them pinnatifid; the lowest are the longest, and again distinctly pinnate, and these second pinnulæ are again a little denticulated. The veins of the pinnulæ pass out from the rhachis of the pinnæ and send up the branches to the lobes or into the secondary pinnulæ and there they are forked. The pinnulæ have a peculiar arrangement on the pinna: only the lower ones begin with a pinnula in the angle of the chief rhachis and that of the pinnæ, while of the upper ones the first is pretty distant from the chief rhachis.

Both the chief rhachis and the rhachis of the pinnæ are broadly winged.

These three different states of the frond I observed in one case on one specimen, while in others I found them separated on different slabs. But with the assistance of that one specimen, all can be referred to the same species; from this different state of the pinnæ and pinnulæ in the several portions of the frond I have called the species "*polymorpha*."

Of the other specimens I have figured some portions on plate xvii which plainly show the various sizes and shapes of the pinnulæ.

This fern has some analogies.

First I must mention McClelland's *Pecopt. affinis*, (Report Geol. Surv. Pl. XIII, Fig. 11 b.) As far as one can judge from the bad figure, there pass out from the rhachis of the pinna a pretty strong midrib into the pinnulæ (of the first order), and from this midrib a secondary vein passes into each distinct lobe of the pinnula (indicating pinnulæ of the second order), and here the secondary veins are forked. This agrees quite well with the character of the nervation in our *Sphenopteris polymorpha*, especially in the larger specimens, and I have no doubt but that this *Pecopteris affinis* of McClell. with great probability belongs to the same fern. The inspection of the original specimen, which will be later figured again, confirms my view.

Amongst other fossil ferns, our species can be compared in some way first with that form which was originally described as *Pecopteris alata*, Bgt.,\* from the Hawkesberry beds in Australia, but which later was ranged with *Sphenopteris*, and recently by Schimper with *Sphenopteris Hymenophyllides*, Schimp. Our species has in common with this the broadly winged rhachis and, besides this, the shape of the upper pinnæ, but the lower pinnæ cannot be compared with ours, the secondary pinnulæ being not so denticulated. Both these species may in the younger states be pretty similar, while differing in the older ones.

The lower pinnulæ of our fern resemble rather those of the *Pecopteris athyrioides*, Bgt.,† now *Sphenopteris athyrioides*, Bgt. sp., from the Yorkshire

\* Hist. d. végét. foss. p. 361, pl. 127.

† l. c. pl. 125, f. 3.

Oolite, only that this latter species has no winged rhachis. Thus, our fern presents some points of resemblance to mezozoic forms only, although it cannot be identified with any one of them.

The same species occurs also in the Barakur group at Talchir (Cuttack) in Orissa.

### Order PECOPTERIDES (ææ.)

An order which is the most frequent in the whole fossil flora, but everywhere are represented certain types and forms which are characteristic of certain strata, although the relations of all to one another cannot be denied.

In the existing flora we find analogues of the fossil *Pecopterides* amongst the *Aspleniaceae*, *Aspidiaceae*, *Acrostichaceae*, and true *Pterides*; therefore in general amongst the *Polypodiaceae*, tribe *Polypodeae*. Only in cases where the fructification is preserved, can one determine the family more exactly; in other cases we can judge only from the venation and therefore only generally. By this proceeding of course it may sometimes happen that forms of the same living genus are taken in the fossil flora as different as long as the fructification is unknown; I may mention for instance the carboniferous *Alethopteris Serli*, Bgt., which is certainly a *Pteris*, and, again, *Lonchopteris rugosa*, Bgt., which in form closely resembles *Alethopteris Serli*, only that it has a net-venation; but we know that in the living genus *Pteris* the same relations obtain: for instance, *Pteris Schiedeana*, Presl., *Pt. comans*, Forst. *Pteris polyphylla*, Presl. have a net-venation, while *Pt. pseudolonchitis* Bory, *Pt. nemoralis*, Willd., and even the common *Pt. aquilina* and a great many others, have free and forked veins with a similar shape of the leaflets.

Mr. Ettingshausen in the above-mentioned work has attempted to distribute the fossil *Pecopterides* (as *Alethopteris*, *Pecopteris*, etc.) amongst the different living genera, as he fancied himself able to do from the venation.

The chief living genera in which Mr. Ettingshausen saw analogies to the fossil *Pecopterides* are shortly the following:—

#### PTERIS, Linn.

*Pteris Serli*, *Pecopteris Serli*, Bgt. (*Alethopteris*).

*Pt. lonchitica*, *Pecopt. lonchitica*, Bgt. (*Alethopteris*).

*Pt. Whitbyensis*, *Pecopt. Whitbyensis*, L. H. etc. (*Alethopteris*).

#### ASPLENIUM, Linn.

*Asplen. Radnizense*, *Pecopt. Radnizensis*, Stbg. sp. (*Cyatheites*).

*Aspl. simile*, *Pecopt. similis*, Stbg., etc.

#### PHEGOPTERIS.

*Phegopt. arguta*, *Pecopt. arguta*, Bgt. (*Cyatheites*).

#### ASPIDIUM.

*Asp. lanceolatum*, *Pecopt. lanceolata*, Stbg.

#### HEMITELIA.

Here are to be ranged most of the fossil *Cyatheides*, etc.

Mr. Schimper, in his 'Pal. végét.', endeavoured to establish a reasonable method, which, however, cannot always be used.

He kept the generic name *Pecopteris* and joined with it the name of the living genus to which he thought the fossil belonged to indicate a subgroup: thus, he has *Pecopteris Cyatheides*, *Pecopteris Aspidides*, etc.; but besides this, the peculiar genus *Alethopteris*, Göpp., which differs considerably from *Pecopteris*. But I think it is better to distinguish not only *Alethopteris*, Göpp., but the fossil genus *Cyatheites* also, and to range with *Pecopteris* only those forms which cannot be united with either of these two.

### Genus *Alethopteris*, Sternberg, 1838.

*Fronda bi- vel tripinnata. Pinnulis plerumque integerrimis nonnunquam denticulatis tota basi adfixis, saepius basi dilatatis ac connatis, rarius subconstrictis, sed etiam connatis; margine nonnunquam reflexo (soros obtegente?\*), nervo medio plus minusve distincto, ex rhachide eggre-diente usque ad apicem continuante, nervis secundariis sub angulo subacuto egredientibus, simplicibus, vel semel (superioribus) vel bis (inferioribus) furcatis, parallelis aut divergentibus†, ad marginem productis. (Fructificatio familiae).*

*Alethopteris* is represented in the existing flora especially by forms of the genus *Pteris*, *Phegopteris*, etc. Of *Pteris* I will mention the common *Pteris aquilina*, *Pteris arachnoidea*, Kaulf., *Pteris Smiethiana*, Prsl., *Pt. flabellata*, Thunb., etc.; of *Phegopteris*, *Phegopteris decussata*, Mett.

From the mezozoic epoch we find described a good number of species, which, however, when compared together show great likenesses as well in the shape of the leaflets as in the venation. This has been lately recognised and acknowledged by several authors.

*Alethopteris Whitbyensis*, Göpp., is the typical form to which a good many of the mezozoic forms can be referred, some of them being even identical with it, others very closely related.

Mr. Schimper (Pal. végét. I. 569) indicated this by speaking of a group of *Alethopt. Whitbyensis*, Göpp.,‡ to which many species were referred.

\* In this case the form agrees with *Pteris*.

† In my Flora of Kach (Pal. Ind. XI, No. 1, 187, p. 22), when giving the diagnosis of *Alethopteris*, I said only "divergentibus," whereas I should have said "parallelis aut divergentibus."

‡ When speaking of *Alethopt. Australis*, Morr., Schimper says: "Cette fougère appartient au groupe de l'*Alethopt. Whitbyensis*, Göpp., groupe qui paraît être propre au terrain jurassique."

In my Flora of Kach (Pal. Ind. XI, pt. 1, p. 22), I also speak of a group of *Alethopteris Whitbyensis*, Göpp. (Lindl. and Hutt.), and on p. 27 enumerate all the species which I think can be brought into any connection with it.

Of our Indian fossils are to be placed here *Alethopt. Whitbyensis*, Göpp. (*Alethopteris tenuis*, Bgt. sp.), *Alethopteris indica*, O. M., *Alethopteris Lindleyana*, Royle sp. M. Saporta\* has re-established for all these mezozoic forms the genus *Cladophlebis*, with which they are to be ranged, and this author has a *Cladophlebis Whitbyensis*, *Cladoph. Rösserti*, etc., both of which latter he considers as scarcely distinguishable; so that I was right when I placed the *Alethopt. indica*, O. M., the near relationship of which to *Alethopt. Rösserti*, Schenk, cannot be denied, in the group of *Alethopt. Whitbyensis*.

Group of *Alethopteris Whitbyensis*† (Schimper 1869, Feistmantel 1876.)

Of Mr. Wood-Mason's specimens one belongs here.

ALETHOPTERIS LINDLEYANA, Royle sp., Pl. XX, Fig. 7.

1869. *Pecopteris Lindleyana*, Royle, Illustr. Bot. etc. Him. Mount. Tab. 2, f. 4.

1849—50. ———— McClelland, Rep. Geol. S. India, Pl. XIII. f. 10. a. b. c.

1845. ———— Unger, Synopsis Plant. foss. 96.

1850. ———— Unger, Genera et Species Plant. foss. p. 171.

1861. ———— Schimper, Pal. végét. I. p. 568.

1876. ———— Feistmantel, Rec. G. S. Ind. IX. 3. p. 76.

*Fronde bi-pinnata; pinnis patentibus, rhachide eorum crassiore; pinnulis tota basi sessilibus, attingentibus, oblonge-ovalibus, margine integris aut sinuatis; nervo medio usque ad apicem excurrente nervis secundariis angulo subacuto egredientibus dichotomis; sporangiis ramis insidentibus.* (Feistmantel ex parte).

Royle was the first to figure this species; but he has given no description; his specimen, too, could not have been a well-preserved one, but it gives at any rate the form of the leaflets.

In McClelland's Report (l. c.) we find added three figures more, which, however, are very badly drawn, as also is his *Pecopteris affinis* (l. c. Pl. XIII. Fig. 11. a. b.), of which fig. 11 must certainly be placed with *Alethopteris Lindleyana*, Royle, while fig. 11 a. is a bad representation of the same fern of which I give figures on pls. xvi. and xvii, and which, as I think, belongs to another type of plants, and I have described it amongst the *Sphenopterides*. The worst thing in McClelland's figures is the veins in the leaflets, which are quite unnatural. So it is also with his figures of *Alethopt. (Pecopt.) Lindleyana*, Royle.

\* Pal. Francaise, Végét. fossiles, Jurassiques et Triasiques, p. 298 et seq.

† *Cladophlebis*, Saporta, Pal. Franc. Vég. foss. Jur. 298.



We can, however, still recognize that we have to deal with an *Alethopteris*, Göpp., as some of the originals are still in the Museum of the Geological Survey.

Mr. Oldham\* from the first compared this *Alethopteris Lindleyana*, Royle, with *Pecopteris Australis*, McCoy. I think there is an analogy in so far as they both belong to the same meozoic group.

Schimper has recently† described this species as *Alethopteris Lindleyana*, Royle, between *Aleth. indica*, O. M. and *Alethopt. australis*, Morr., and says of it (p. 569), "*Cette espèce paraît également appartenir au group de l'Alethopteris Whitbyensis*, etc."

The figures of Royle and McClelland were all taken from sterile fronds. Amongst Mr. Wood-Mason's specimens is a fructifying pinna, which in the form of the leaflet agrees perfectly with that of *Pecopt. Lindleyana*, Royle (l. c.), so that I do not doubt but that I have this species before me, and I must consider it as a fertile frond of *Pecopteris Lindleyana*, R.

It is only a fragment of a pinna with 4 pinnulæ on each side. The form of the leaflets besides agreeing with Royle's figure (l. c.) shows also a similarity to certain forms from the Rajmahal Hills which I consider to belong to the *Alethopteris indica*, O. M., and of which one specimen will be figured on Pl. XXXVI of the continuation of the Rajmahal Flora, now in the press and shortly to be issued.

The specimen under discussion is the second instance of a fern found in fructification in the Raniganj field‡; fructifying ferns are as yet very rare, and we know besides these two specimens only *Glossopteris indica*, Schimp., from Kamti (Nagpur district) with fructifications preserved.

The rhachis of the pinna is pretty thick, the pinnulæ broadly ovate, connected at the base, with a slightly waved margin.

The chief veins fine, as also are the secondary ones, which seem forked; the sporanges inserted on the secondary veins, on the surface of the pinnula, about midway between the midrib and the margin.

There are generally from six to eight sori in each row.

From the manner of fructification and from the shape of the leaflets, we could perhaps trace an analogy between our species and some forms of the genus *Polypodium*, perhaps *Polypodium spectabile*, Sprengel (Kaulf.), *Polypodium concinnum*, Presl. (and others), *Polypodium submarginale*, Sprengel, *Polypodium amplum*, Presl., and other species. (Some of these are also described as *Phegopteris*.)

\* Mem. G. S. Ind. Vol. II. p. 328.

† Pal. veget. I. pp. 568, 569.

‡ A fructifying pinnula, as I suppose, also of *Alethopteris (Pecopt.) Lindleyana* is amongst McClelland's originals, but was never mentioned.

Amongst fossils the non-fructifying frond can be compared, as I have said, with some fronds of our *Alethopteris indica*, O. M., from the Rajmahal Hills.

*ALETHOPTERIS* comp. *WHITBYENSIS*, Göpp., Pl. XXI, Figs. 6, 6a.

Two pinnulæ of a fern which I can only place with this species, as they are so near that I do not think it advisable to separate them.

Our pinnulæ are more closely allied to Brongniart's *Pecopteris tenuis*,\* from the Yorkshire Oolites; but in my Kach Flora† I have shown all the species which are synonymous with or related to this *Alethopt. Whitbyensis*, Göpp., and amongst them *Pecopt. tenuis*, Bgt., is the first. There is nothing peculiar in the occurrence of this species in our Raniganj Series, since we know that the fossils of this group are more closely related to one another than was formerly thought, and since Saporta‡ has shown that this *Cladophlebis Whitbyensis*, Göpp., and *Cladophlebis Rösserti*, Schimp., (a Rhætic form) are almost identical. To the *Pecopt. Rösserti* (*Cladophlebis*) our *Alethopt. indica*, O. M., from the Rajmahals is very closely allied, and to this latter again the *Alethopt. Lindleyana*, Royle sp., of the Raniganj Series; and now we have the *Pecopt. tenuis*, Bgt., identical with the *Alethopt. Whitbyensis*, Göpp.

Type *Phegopteris*, Mett.

There is a very big specimen of a fern which from a palæontological point of view is an *Alethopteris*. But a closer examination shows that the specimen has a very close relation in the existing flora, and it is amongst the *Aspidiaceae* with single secondary veins.

There is the genus *Phegopteris*, which is in some forms almost identical with our fossil, our *Alethopteris* agreeing especially with *Phegopteris decussata*, Mett. I could at once establish on this specimen this living genus in the fossil flora, but in conformity with the palæontological classification, I retain the generic name *Alethopteris*, using *Phegopteris* to form the specific name, and placing this new species in the type *Phegopteris*. This fossil is, therefore, especially of interest as so closely resembling a living genus; but there are some differences, as we shall see in discussing the species.

*ALETHOPTERIS PHEGOPTEROIDES*, n. sp., Pl. XVIII.

*Fronde valida, bipinnata; rhachide crassa, punctulata; pinnis sub angulo subrecto e rhachide egredientibus, rhachide earum crassiore; pinnis mediis longissimis basin apicemque versus attenuantibus; pinnulis oblon-*

\* Hist. d. végét. foss. Pl. 110. f. 3. 4.

† Kach flora in Pal. Indica, Ser. XI. 1. 1876, pp. 22—25.

‡ Végét. foss. Terr. Jur. de France, p. 298 et seqq.

*gis incurvatis maxime approximatis, omnibus aequalibus oblique insertis, primis solum verticaliter adfixis et paulo latioribus, omnibus ad bases connatis; nervo primario pinnularum distincto ad apicem promotum; nervis secundariis singulis sub angulo acuto egredientibus. Fructificatione non obvia.*

A big slab of shale contains two fronds, besides smaller fragments, of this interesting fern.

The chief characters which are to be observed are in the pinnulae; these are oblong, closely set, a little incurved and oblique to the rhachis of the pinna, only the first pinnulae near the chief rhachis being vertically inserted, and a little broader than the others, so that they are distant from them; the midrib is pretty thick and reaches to the apex; the secondary veins are single, passing out at an acute angle from the midrib; the lowest two in that portion of the pinnula which is directed from the chief rhachis are arcuate, the rest being quite straight.

The pinnae are longest in the middle of the frond and are shorter at base and towards the apex. The chief rhachis pretty thick.

I have figured two portions of the specimen; one of them shows two pinnae, which are entire, with the end leaflets. Two other figures illustrate the disposition of the veins and the bases of the pinnulae and the top portion.

From this we see plainly the relation with the *Aspidiaceae* and especially with *Phegopteris*, of which *Phegopteris decussata* is the nearest.

One sees well in our specimen the triangular empty spaces between adjoining pinnulae, where these are connected: these contain no veins.

This type of fossil is quite peculiar, and I do not know any form in the palæozoic strata at all analogous to it.

But on the other hand there is in the Trias a form which was first described as *Pecopt. Stuttgartensis*, Bgt.,\* but later by Schimper† was placed in a new genus *Lepidopteris* (in the *Pecopterides*).

On Brongniart's figure, which, however, is not quite distinct, one sees very distinctly the single veins arranged in a similar way to our specimen, but I think the shape of the leaflets is different, as they are a little longer and not so incurved, and they are also more deeply separated, but I do not know if the punctuation of the rhachis can be considered as a sufficient character, as all ferns present it more or less.

Into this genus *Lepidopteris*, Schimper placed also the rhætic form; *Asplenites Ottonis*, Schenk, as *Lepidopt. Ottonis*, Schimper, of which we find near relations amongst the Rajmahal fossil plants.

I think the *Pecopteris arguta*, Bgt.,‡ from the coal-measures, belongs

\* Histoire d. végét. fossiles, 1820, Pl. 130, f. 1.

† Pal. végét. I. p. 572, Pl. XXXIV. f. 1.

‡ Brongniart, Hist. d. végét. foss. Pl. 108, f. 3. 4.

to the same type of fossils, but our species is much more nearly allied to the living *Phegopteris* than to any fossil species,

### Order TÆNIOPTERIDES.

In my preliminary 'Note on the Flora of the Damuda Series'\* I have already pointed out that the Damúdas are by no means without a *Tæniopteris*, but that, on the contrary, forms of this order had been known for several years from these rocks; they occur especially in the Kamthi and Raniganj groups (both of which, however, are of the same horizon), and also in the Barakur group.

The majority of the *Tæniopterides* belong, as we know, to post-palæozoic epochs, the mezozoic epoch being especially rich in species of this order. There are, it is true, some forms in the Permian formation, but these are very rare and scarcely of any importance, while in the mezozoic they are frequent.

In the occurrence of this genus in the Damúdas, I see a connecting link between the lower and upper Gondwanas, as in these latter (Rajmahal Series) analogous forms are very frequent.

Brongniart† knew only the one genus *Tæniopteris*, but since his day other discoveries have been made, so that Schimper in his 'Palæont. végét.' could give a pretty complete division of this order.

In my Kach flora‡ I have given a close discussion of this order and need therefore only shortly indicate here Schimper's division; he distinguishes:—

1. *Tæniopteris*, which he restricts to the few palæozoic forms.
2. *Macrotaeniopteris*, Schimp. especially mezozoic forms; of Indian specimens belong here the greatest part of the broad-leaved forms from the Rajmahal Hills and besides these some forms from the Kamthi, Raniganj, and Barakur groups.
3. *Angiopteridium*, Schimp., a mezozoic type, to which especially some of the Rajmahal species belong and perhaps one from the Kamthis.
4. *Oleandridium*, Schimp., begins in the mezozoic epoch. We have one species from Kach.
5. *Danaeopsis*, a Triassic form, but here found, as I think, in the Liassic Rajmahal group.

*Marattiopsis*, Sch., and *Danaeides*, Schimp., are of no interest for us. From this division the living affinities are plainly seen, and they particularly are—

*Aspidium Nidus* for *Macrotaeniopteris*.

*Angiopteris* for *Angiopteridium*.

\* Rec. Geol. Surv. IX. 3. p. 74.

† Prodrome and Histoire, 1828.

‡ Pal. indica, XI. 1. 1876.



*Oleandra* for *Oleandridium*.

*Danaea* for *Danaeopsis*, Heer.

From our Raniganj Series we have to deal only with *Macrotaeniopteris*.

Genus *Macrotaeniopteris*, Schimper, 1869.

Schimper, Palaeontol. végét. I. p. 610.

*Frondibus simplicibus, speciosissimis, plus minus elongato, obovatis, obtusis vel acuminatis nonnunquam etiam apice emarginatis, integris, raro irregulariter pinnatifissis, interdumque denticulatis. (Fructificatione Aspidiacearum, Schimp.)*

With this genus Mr. Schimper placed all the broad-leaved mezozoic forms which are allied to *Neottopteris Nidus*.

Our broad-leaved *Taeniopterides* from the Rajmahal Hills belong to this genus.

To the palaeozoic forms Schimper would restrict the generic name *Taeniopteris*, Bgt., in which he is, as I think, quite right, although there is one species in particular, *Taeniopteris abnormis*,\* from the Permian in Saxony, which has nearly all the characters of *Macrotaeniopteris*, Schimp., the only difference to be detected being in the very close-set veins.

In a paper on the *Taeniopterides* from Chemnitz in Saxony,† Dr. Sterzel has redescribed the *Taeniopteris abnormis*, Gutb., and has found that this species is very closely allied to several mezozoic forms, amongst which are the *Macrot. gigantea*, Schenk., and our two Rajmahal species *Macrot. lata*, Oldh. Morr., and *Macrot. Morrisi*, Oldh.‡ Dr. Sterzel considers, therefore, this Permian species also as a *Macrotaeniopteris* and as a precursive form of several of the mezozoic species.

The relations of our Rajmahal species with the Rhætic *Macrot. gigantea*, Schenk., I have already pointed out in my first note on the fossil plants from the Rájmahal group (Rájmahal Hills).§

MACROTÆNIOPTERIS DANÆOIDES, Royle sp. (McClell.)

Pl. XIX, Figs. 1, 2 & XXI, Fig. 1.

1839. *Glossopteris danaeoides*, Royle, Illustr. Bot. etc. Him. M. Tab 2.

1849-50. ———— McClelland, Rep. Geol. Surv. India, XV. f. 1.

1876. ———— Feistmantel, Notes on the several floras in India,

Rec. Geol. Surv. Ind. IX. 3. p. 74. Ibid., IX. 4.

*Frondē speciosa, oblongo-ovata, apice obtuse acuminata, basi attenuata obovata, distincte pedicellata, ad 34 cm. longa et 10 cm. lata, subcoriacea;*

\* Gutbier, Versteinerungen des Rothliegenden in Sachsen, 1849, Pl. VII. f. 1. 2.

† Ueber die Tæniopteriden von Chemintz in Sachsen N. J. f. M. Geogn. 1876.

‡ This however only partly.

§ Rec. G. S. Ind. IX. 2. p. 36.

*rhachide mediocri striata; nervis secundariis sub angulo suberecto e rhachide egredientibus, usque ad 1.5 mm. distantibus, marginem versus paulo incurvatis, crassiusculis; simplicibus et furcatis alternantibus, furcatione differentibus in partibus longitudinis nervorum exhibita.*

The species was first described by Royle (l. c.) as *Glossopteris danaeoides*, although there is not anywhere the slightest anastomosis of the veins, which on the contrary are all parallel and dichotomously forked.

This fern belongs undoubtedly to the same species which McClelland later described as *Taeniopteris danaeoides* also from the Raniganj (Burdwan) coal-field; but his figures (Pl. XV 1, 1a, 16) are very incorrect, especially the enlarged portion (Fig. 1b). But we can at any rate certainly conclude from them that this *Taeniopteris* was found a second time in the Raniganj field, as McClelland's specimens do not differ from those of Royle. Later the same species has been brought by Mr. Hughes from the Jherria coalfield, where, as Mr. Hughes assures me, it is pretty frequent, though I can find only one specimen in our collections;—and now Mr. Wood-Mason has brought pretty numerous specimens of it from Raniganj, and his statement is that he brought only the very best, while he left behind great numbers of fragmentary ones. Also in the Barakur group in the Rajmahal Hills (near Burgo) the same species has occurred.

*Taeniopteris* is, therefore, as is seen from this examination, not wanting in the Raniganj field and from the Damudas generally, the more so if we consider that from the Kamthis also several specimens are known.

I have figured two specimens and two enlarged portions; the two figures complete one another, one being the basal, the other the apical portion.

The chief character of this species is the very distant veins; these pass out from the rhachis, which is proportionally thin, at nearly right angles, and run almost straight to the margin, where they are a little incurved; the veins are about 1.5 mm. apart; simple and forked veins alternate; the furcation does not follow any constant law; some of the veins are forked at the very base and may be forked again, others more towards the middle, and others quite close to the margin.

The apex is obtusely acuminate; at base the frond is obovate and apparently pedicellate.

The biggest frond is 10 cm. broad and must have been at least 34 cm. long.

By the great distance of the veins apart this species differs from all others, but most approaches that from the Rajmahal hills which Messrs. Oldham and Morris described as *Taeniopteris musaeifolia*,\* but which is, as I think, barely distinguishable from *Taenopt. lata*, O. M.; the only differences detected by Mr. Oldham being the slightly more distant veins and the more coriaceous consistence of the frond.

\* Rajmahal Flora, Pal. Ind. 1862, Pl. IV. f. 1.

But these Rajmahal species approach on one hand pretty nearly the Rhætic *Macrot. gigantea*, Schenk,\* on the other hand those forms from the Kamthis which I have lately briefly described as *Macrot. Feddeni* Fstm.,† and which are all to a certain degree related to that Permian *Taeniopt. abnormis*, Gubb., of which I have already spoken.

These species are all based chiefly upon the different distances apart, the formation, the direction, and the thickness, of the veins, and if we compare all together, then we have the following table:—

1. *Macrotæniopteris danaeoides*, McClell., with the most distant veins, nearly straight.
2. *Macrotaeniopteris gigantea*, Schenk., and the Rajmahal species, *Macrot. lata*, O. M. and *Macrot. musaeifolia*, O. M., with veins almost equally distant.
3. *Macrot. Feddeni*, Fstm., with pretty close veins, a little oblique.
4. *Taeniopt. (Macrotaeniopt) abnormis*, Gatt., with very close and almost straight veins.

For us it is a great satisfaction to find the genus *Macrotaeniopteris* so frequently represented, as Mr. Oldham to the last maintained that no *Taeniopteris* are in the Damudas,‡ and in a letter to Mr. W. B. Clarke, which this latter gentleman has published in his ‘Remarks on the Sedimentary formations in New South Wales,’ 3rd Edition, 1875, p. 29,§ Mr. Oldham maintains that in the Panchet group also no *Taeniopteris* has been found, although it occurs.

Amongst all the numerous specimens not one occurred which showed any trace of fructification, so that it cannot be decided with certainty to which living genus the species should be referred, but as far as can be judged from the form of the leaf and from the veins I would refer it to some form of *Acrostichum*, for example, *Acrostichum hybridum*, Bory. Its fossil allies have been already indicated.

#### MACROTENIOPTERIS sp.

Another specimen of *Macrotaeniopteris* occurred ; but it unfortunately is so badly preserved that it cannot be figured nor any exact description of it given. It is only a portion of a leaf-surface, no rhachis being preserved.

\* Schenk, Flora des Grenzschiehten, Tab. XXVIII. p.146.

† Records G. S. Ind. IX. 4.

‡ In Mem. G. S. Ind. II. p. 329 he said so quite plainly.

§ In the Mines and Mineral Statistics of New South Wales, 1875, where Mr. W. B. Clarke's Sedimentary formations, etc., is included, page 175.

It shows that the leaf was much bigger than those of the species just described, and that the veins are much closer together and are not so straight and stiff as in *Macrotaeniopteris Feddeni*, Fstm. from the Kamthis, so that I would not venture to identify it with this species.

I mention this specimen only to show that another kind of *Macrotaeniopteris* also occurs at Raniganj besides *Macrota. danaeoides*, and I am sure that further investigations will furnish more fossils of this kind. These *Macrotaeniopterides* establish a palæontological relation between the lower and upper portions of the Gondwana system.

Type *Vittaria*, Swartz.

Genus *Palæovittaria*, nov.

On pl. xix, fig. 3 is figured a splendid specimen, which from the characters of the veins must be considered a fern. There is a distinct midrib (*rhachis, costa*) in the lower part of the frond, pretty broad, becoming thinner upwards and vanishing completely in the apical portion.

The secondary veins pass at very acute angles towards the margin, where they are a little incurved; they are single and forked as in *Taeniopteris*, but the specimen cannot be placed with this genus, and recalls, as Dr. Kurz informs me, in this character the nervation of the living genus *Vittaria* only, so that I use for our fossil the generic name *Palæovittaria*.

Diagnosis.—*Frondibus simplicibus, oblongato-ovalibus, costa apicem versus evanescente. Nervis secundariis sub angulo acutissimo egredientibus. Nervatio Vittariæ.*

There is only one species, which I call

*PALÆOVITTARIA KURZI*, n. sp., Pl. XIX, Figs. 3—4.

*Frondibus aggregatis, simplicibus, oblongato-ovato-spathulatis, margine integris, nonnunquam apice excisis, nervo medio (costa) inferiore in parte crassiore, dimidiam partem versus evanescente; nervis secundariis sub angulo acutissimo e rhachide exeuntibus, in parte apicali radiantibus, simplicibus et furcatis; marginem versus incurvatis, sequente precedentem ea in parte attingente. Fructificatione non obvia.*

About 9 fronds come out from a common point; they are generally oblong-spathulate, entire on the margins, but they are sometimes deeply emarginated and therefore bilobate at the apex.

The chief characters are in the midrib and in the secondary veins; the former is well developed and distinct in the lower portion of the leaf, but in the upper portion this vein vanishes, becoming dissolved in the secondary veins.



The secondary veins pass out from the rhachis at a very acute angle pretty straight towards the margin, where they are incurved. In the apical portion, where is no midrib, the secondary veins radiate fan-wise. The secondary veins are alternately single and forked; the furcation occurs at different parts of the length of the veins, all of which are regularly equally distant from one another. I cannot observe any distinct peduncle; the leaf becomes more attenuate towards the base and the rhachis thicker, until at last only the latter remains.

It seems certain that the aggregation of the leaves is not due to an insertion on a common stalk, but rather to associated growth out from the rhizome. As I have said, this form has no analogue in any existing fern except *Vittaria*, where also the rhachis vanishes towards the apex and the secondary veins pass out at a very acute angle from it; the only difference being that our fern has many more secondary veins, and that the frond in proportion to its length is much broader. I have obtained from Mr. Kurz a good collection of Indian *Vittariæ* for comparison, and of these the *Vittaria intermedia* from Java comes nearest to ours. But amongst the American forms are some still broader ones, which would come still nearer.

Amongst fossils nothing is as yet known at all like our fossil plant.

If we take the single leaf and consider only its shape and the general disposition of the veins, then we find an approximate similarity in *Sagenopteris*, but here the leaves come out from a common stalk and the secondary veins anastomose so as to form a net-venation.

Amongst the *Taeniopterides* we find scarcely any similarity, as all these have a rhachis continuous to the apex of the frond, and the angle at which the secondary veins pass out from it, as for instance in *Taeniopteris Morrisi*, Oldh.,\* or in *Phyllopteris plumula*, Sap.,† far less acute than in our fossil.

#### IV.—DICTYOPTERIDES.

This order includes all ferns with net-venation. This is again only a palæontological order, for in the same living genera are forms with forked, as well as with netted veins, for instance, in *Pteris*, *Asplenium*, etc.

But there is yet a peculiarity: it is that most of the ferns with net-venation occur in the mezozoic epoch, without any corresponding forms with free veins, while in the palæozoic epoch the ferns with net-venation are very rare, those with free veins predominating. In the palæozoic we have mostly only *Lonchopteris*, Bgt., which has its analogy in *Alethopteris*, and *Dictyopteris* with complete analogy in *Neuropteris*; so that the order *Dictyopterides* (eae) can very fairly be considered to be a mezozoic one.

\* Oldham and Morris, Rajmahal Flora, Pal. Indica, 1862, Pl. III, f. 1.

† Saprota, Végét. foss. de France (Palæont. Française), Pl. LXIII, f. 6.

There are a good many genera which to a great extent have living analogies, and those sometimes very close.

In Schimper's 'Palæontologie végétale,' p. 737, we find the whole sequence of genera which at that time were known; 15 genera being enumerated.

Of these two occur in our Raniganj Series.

But to Schimper's list must be added, *Gangamopteris*, McCoy, first described as *Cyclopteris*, but having also a net-venation.

To this genus belongs also that fossil from the Talchir which until recently was generally quoted as *Cyclopteris*, but which lately I described as *Gangamopteris cyclopteroides*; of this genus I will describe another species in this present paper.

#### Genus *Belemnopteris*, nov.

*Fronde simplici late sagittaeifolia pedunculata. Nervis primariis tribus, medio crassiore, ceteris anastomosantibus.*

Amongst Mr. Wood-Mason's specimens are two, of which one is tolerably complete and has an arrow-like shape, with 3 chief veins, one stronger passing into the leaf, two others a little thinner into the two basal lobes; the other venation is netted.

It strongly reminds one of some living ferns.

1. First we have *Gymnogramme sagittata*,\* a *Polypodiaceae* which formerly was described as *Hemionitis sagittata*, Fée., with which the *Hemionitis cordata*, Hook. and Grev. (*Hemionitis cordifolia*, Roxb.),† is identical; of this later Mr. Kurz has lent me specimens from Dacca.

With this fern our fossil has little more than the shape of the leaf and perhaps also the primary veins in common, while in the net-venation the two are rather different.

2. There is another fern with which our fossil can be compared, especially as regards the net-venation: this is *Pteris sagittaeifolia*, Raddi‡; this fern is narrower than ours, but the disposition of the 3 primary veins, and the net-venation particularly, agree well with the same in our fern.

Of course, only the fructification can decide to which of these two our fossils should be placed, but as none is to be seen and as our fern cannot be identified with either, on the contrary, presents characters of both, I consider myself justified in establishing a new genus.

It is of very great interest (1st) as it is a form so closely allied to living ones, and (2nd) as it is a fern with a net-venation.

\* See Ettingshausen, Farrenkräuter der Jetztwelt, etc., 1865, p. 59, Pl. XXXI, f. 9.

† See Beddome, Indian ferns (of South India), Pl. LII. p. 18; also Lowe, Ferns, etc., Vol. VII, Pl. XXXVIII, p. 93.

‡ Ettingshausen, l. c., p. 104, Pl. LXXI, f. 3.

**BELEMNOPTERIS WOOD-MASONIANA**, n. sp., Pl. XX, Figs. 1—2.

*Fronde simplici, late sagittaeifolia, apice obtusa, margine integerrima, tota ad 10·5 cm longa, lobis obtuse acuminatis longioribus (5·3 cm longis) ; nervis primariis tribus ; uno crassiore in folii superficiem excurrente, duobus aliis tenuioribus, in lobos currentibus, omnibus tribus apicem versus attenuantibus ; nervis secundariis sub angulo subacuto egredientibus, anastomosantibus, retia plerumque hexagonalia, sed etiam polygonalia, formantibus. Fructificatione ignota.*

Of the relations of this fern I have already spoken when discussing the genus ; they are only in the living flora, nothing like it being known amongst fossils.

The frond is simple, is shaped like a broad arrow, at the apex obtuse ; the margin entire, slightly arcuate, the total length 10·5 cm ; the basal lobes obtusely acuminate, pretty long (5·3 cm.). The chief characters lie in the veins : there are three chief veins, one passing into the surface of the leaf, the two others, a little thinner, into the two basal lobes.

The secondary veins pass out at a subacute angle so as to form a net-venation with hexagonal or polygonal meshes.

This is one of the finest specimens in Mr. Wood-Mason's collection.

Genus **Gangamopteris**, McCoy, 1875.

I have already had occasion to mention this genus in my first note on the Damuda fossils,\* when speaking of *Gangamopteris cyclopteroides* from the Barákars being identical with the species in the Talchirs.

In another paper† I have described another *Gangamopteris* from the Kamthis as *Gangamopt. Hughesi*, which is different from, though closely related to, the species from the Barákars and Talchirs, a wider venation constituting the difference.

I now describe a third, differing from both of these by its very wide net-venation.

I think it will not be considered useless and superfluous to repeat that this genus *Gangamopteris* occurs in true mezozoic rocks in Victoria, and that nothing of the kind is as yet certainly known from the lower portion of the New South Wales coal-strata.

Our new *Gangamopteris* is again a form to which some analogies are to be found in the living flora.

**GANGAMOPTERIS WHITTIANA**, n. sp., Pl. XX, Figs. 3—4.

*Fronde simplici, late ovato subrhomboidali inaequilaterali, integerrima, obtuse acuminata ; costa nulla, sulco medio tantum indicata ; nervis ceteris omnibus e basi duobus in directionibus marginem versus radiantibus, omnibus anastomosantibus, retia valida, oblonge hexagonalia aut polygonalia formantibus. Fructificatione non obvia.*

\* Rec. G. S. Ind. Vol. IX. 3.

† Ibid., IX, 4.

I name this fine species (of which two specimens, both of them figured, are in Mr. Wood-Mason's collection) after Mr. Whitty of Kurhurbáli, who last year increased our knowledge of the Kurhurbáli plants by four very interesting species all on the same big slab of shale.

It differs from both those already described by me, as well as from all described by Mr. McCoy from Australia.

Our specimen shows a broadly ovately subrhomboid frond, which besides seems obliquely shaped; the apex is obtusely acuminate; there is no midrib as in this genus generally, this being indicated in the middle only by a slight furrow, from which the secondary veins pass in two directions towards the margin, which is entire; the secondary veins all anastomose and form large oblongly hexagonal or polygonal areoles, larger than in any known species of the genus; the areoles are largest in the middle, becoming smaller towards the margin.

Fructification not observed.

This very fine fern has an apparent analogy to the living genus *Antrophyum*, and to those forms of it which have no midrib; and there are amongst the Indian living *Antrophyum* some species to which our fossil can be compared. I refer especially to *Antrophyum latifolium*, Bl.\*, from the Khasya Hills, of which Mr. Kurz has lent me several specimens for comparison. I think this is the only fern to which our fossil can be referred. If this be right, it may well be doubted whether the other two species of *Gangamopteris* should be referred to the same living forms; it is rather possible that this genus also is only a palæontological one, for both the other species of it have the leaves differently shaped, although the disposition of the veins in them is similar.

#### Genus *Glossopteris*, Bgt., 1828.

*Frondibus simplicibus* (?), *elongato spathulatis, apice obtusis vel acuminatis*, "*costa usque ad apicem continuante*," *nervis secundariis anastomosantibus*.

This is the famous genus which has caused so much confusion in the determination of the age of our Damúda Series and the Australian coal-strata.

As I have prepared a monograph of it, I will only briefly speak of it here.

a. In Australia *Glossopteris* is known from rocks (the Australian coal-strata) wherein several strata are to be distinguished; the lowest of these is marked by a numerous marine fauna of generally carboniferous alliances. With these some forms of *Glossopteris* occur, though rather rarely.

\* Beddome, Ferns from British India, etc., Part XII, Pl. CLXXVI.



b. In the upper coal-strata no marine fauna is found. *Glossopteris* is very frequent, and is associated with other plants with no carboniferous characters at all.

c. Below the lower portion of the coal-strata is a formation with a true lower carboniferous flora and the same marine fauna, of which no trace is in the upper (Newcastle) coal-strata.

d. From this it would follow that the lower coal-strata, with marine fauna of carboniferous age, had been a long time deposited, or that the carboniferous period had passed away, when the upper coal-strata were formed, or when that period began when *Glossopteris* was especially developed, with other plants which contrast with those of the lower portion.

When later the *Glossopteris* was found frequently in the Damúda Series, these were at once compared with the Australian lower coal-measures,\* although no trace of any marine organism had ever been found in them, and only a flora occurred which was opposed to such a comparison.

I think our Damúda Series, containing only a flora, cannot be compared with the lower Australian coal-strata at all, which contain hardly anything but a marine fauna.

Such transitional forms as *Glossopteris* in Australia we find here in India also.

So in the Damúda Series and the Panchet group the same *Schizoneura Gondwanensis*.

In the Rajmahal group and in the Jabalpur-Kach group are the same two species of *Ptilophyllum*, Morr., and yet there is a difference in age.

In the Salt Range in India we find in the carboniferous strata on the one hand the Devonian genus *Goniatites*, on the other the mezozoic genera *Phylloceras* and *Ceratites*.

In the Trias of the Salt Range we find again the same *Bellerephon* (a purely carboniferous genus) which in the carboniferous limestone is already frequent, and yet all these strata are different.

So is it in Australia too, *Glossopteris* survives from the lower coal-strata in the upper ones, the former being characterized by a marine fauna.

Here in India it is also of no direct influence on the determination of age, while the other plants with which it is here associated certainly are; it indicates of course only for the whole Damúda Series the same age, as no animal fossils contradict.

But yet another point must be mentioned: most of our species of *Glossopteris* are different from those of Australia, and all the other plants in our Damúdas are much more closely connected with European forms than with any in Australia.

\* T. Oldham, Mem. G. S. Ind. II.

I have reported on this subject in my first note on the Damúda fossils,\* and have done so recently more at length†; so that here I will be very brief.

1. We must acknowledge the existence of *Glossopteris* in Australia during the time of the lower coal-strata, the character of which is expressed by a most predominant marine fauna.

2. The carboniferous character of the strata ceased with the extinction of the carboniferous fauna, *Glossopteris* still surviving and becoming much more frequent in the succeeding period, which is marked by a flora only indicative of a mezozoic age.

3. In India *Glossopteris* is very frequent too, but mostly under different forms and associated with no fauna, but with a tolerably abundant flora, the alliances of which are unmistakably mezozoic and triassic.

As to the affinities in the living flora, they can be partly found out. In the Kamthis there occur pretty frequently specimens with a fructification consisting of very well-marked sporanges in the areoles, indicating the fructification of the genus *Polypodium*; and this might be the case also with a great many of the others, while a good many of the Raniganj species remind one, in the venation, of the genus *Antrophyum*, and of this those forms with a midrib; we would have, therefore, here also a relation of some of the *Glossopteris*, Bgt., to *Gangamopteris*, McCoy, parallel to that which we find in *Antrophyum*, i. e., forms with and forms without midrib. In the Australian *Glossopterides*, Mr. Carruthers seems to have observed a fructification along the veins; this would perhaps indicate some difference between ours and the Australian ones.

At present I have to mention only two species as contained in Mr. Wood-Mason's collections, one of them in fructification.

GLOSSOPTERIS ANGUSTIFOLIA, Bgt., Pl. XXI, Figs. 2—4.

1828. Brongniart, Hist. des. végét. foss. I. p. 227, Pl. LXIII. f. 1.

1845. Unger, Synopsis Plant. fossil, p. 95.

1850. Unger, Genera et Species Plant. foss., 169.

1876. Feistmantel, Rec. G. S. India, IX. 3. p. 72.

*Fronde angusta usque ad 18—20 cm. longa et 1·7 cm. lata; apice acuminata, rhachide (costa) crassa, nervis secundariis sub angulo acuto egredientibus, omnibus anastomosantibus; retibus, rhachidi proximis, maximis, marginalibus oblongis angustissimis. Margine marginato, fructificationem indicante.*

This species was first described by Brongniart (l. c.) from Raniganj; but he had only incomplete specimens, which, however, were given again in Schimper's 'Palæontologie végétale.'

\* Rec. G. S. I. IX. 3.

† Ibid, IX. 4.

In Brongniart's figures the veins particularly are not rightly figured, and the margin also is incorrect. This author also made the same mistake in the *Glossopteris Browniana*, drawing the veins as anastomosing only to the middle of the leaf-surface (on both sides of the stalk) and thence to the margin dichotomous only; while they in reality anastomose throughout until they reach the margin. The same is also the case with *Glossopteris angustifolia*, Bgt. In Brongniart's figures we find some nets on each side of the rhachis only, and then the veins are regularly dichotomous. This is not so.

Mr. Wood-Mason has brought several specimens, of which I give three figures, and which show the relations better.

The frond is rather narrow, about 1·7 cm. broad and only about 18—20 cm. long; the rhachis is proportionally very thick (2 mm.) and reaches to the apex; this is quite acuminate; the secondary veins pass out at a pretty acute angle from the rhachis and are there tolerably thick and form tolerably large polygonal oblong areoles; but from here they are resolved suddenly into many branches, which form oblong and narrow areoles up to the margin; here they are curved along the margin in such a manner that one always catches the next so as to form areoles even on the margin, Brongniart representing them as ending straightly.

On both sides of this marginal ending of the areoles one can observe with the lens a smooth line running along the whole margin (see fig. 2a. Pl. XXI), of which in Brongniart's figure nothing is to be seen.

Does this indicate a marginal fructification? If so, then we have perhaps an analogy in *Pteris* or *Schizoloma*.

This discovery of Mr. Wood-Mason's modifies my statement in Rec. G. S. Ind. IX. 3, p. 72, when I stated, that I had not rediscovered any specimen from India: this was right as to our collection, Mr. Wood-Mason's specimens having been acquired later. The specimen which I mentioned (on the same page) as from the upper portion of the Australian coal-strata, now appears different from our Indian *Glossopt. angustifolia*, Bgt. as above characterised.

#### GLOSSOPTERIS COMMUNIS, Fstm., Pl. XXI, Fig. 5.

*Fronde simplici, variante, sed plerumque speciosa, integerrima, ovato-oblonga, apice elongato-acuminata, basi attenuata in rhachidem decurrente, rhachide crassa usque ad apicem currente, nervis omnibus anastomosantibus, retia oblonga, angustissima formantibus. Fructificatione ignota.*

Of this species I have given only a portion of a frond, twice enlarged to show the character of the net-venation; in my monograph on *Glossopteris* I shall have occasion to figure a good many nice specimens.

This species, the commonest near Raniganj, is also not wanting in other places. It resembles in shape pretty well the *Glossopteris indica*, Schimper, but the net-venation is different, as also is that of the Australian *Glossopteris Browniana*, Bgt.

I have completed the description a little from other specimens, to make myself understood.

The frond is simple, oblong-oval, the apex oblongly acuminate (as in *Glossopt. indica*, Schimp., while it is obtuse in *Gloss. Browniana*, Bgt.); at base the frond is attenuate, running down into the rhachis; the rhachis thick, reaching to the apex; the secondary veins all of pretty equal thickness, all anastomosing; the areoles are all pretty equally oblong and very narrow (while in *Glossopt. indica* they are more polygonal and larger next the rhachis), reaching to the margin. The fructification of this species is unknown to me, but in *Glossopteris indica*, Schimp., it consists, as I have mentioned, of round sporanges in longitudinal rows.

At Raniganj the *Glossopt. indica*, Schimp., seems rarer than *Glossopt. communis*, Fstm., but both species seem to have been of nearly the same size. In the Kamthis *Glossopt. communis* is frequent enough, and it occurs frequently also in the other groups of the Damuda Series.

From Raniganj there are known besides a great many *Glossopterides*, which, however, I will describe later.

#### Genus *Sagenopteris*? Bgt.

If I am right in placing *Glossopt. acaulis*, McClell.,\* in *Sagenopteris*, Bgt.,† then the specimens from Mr. Wood-Mason's collection figured on Pl. XX, Figs. 5, 6, must be placed with it too, as I believe them to belong to the same species which McClelland called *Glossopteris acaulis*. These two specimens do not come out quite plainly from a common stalk, but their relative position to each other on the stone would lead one to suppose that they do so; that they are identical with that species of McClelland seems also to be indubitable, as the net-venation is of the same kind.

What induced McClelland to apply the specific name "*acaulis*" to a plant the leaves of which are so very distinctly pedicellate, I cannot understand, and I think that in this case there will be no objection to my rejecting this specific name, especially as McClelland's figure is so bad, more resembling a dicotyledonous leaf.

It is true that the real *Sagenopteris* from the Rhætic and Lias had not so many, nor such distinctly pedicellated, leaves, but the general disposition of the leaves in our specimens, and their insertion on a common

\* Report Geol. Surv. 1848-49, Pl. XIV. f. 3.

† Rec. Geol. Surv. Ind. IX. 3, p. 73.



stalk, the net-venation, and the midrib vanishing towards the apex, seem to justify my placing this form under *Sagenopteris*, Bgt.

SAGENOPTERIS POLYPHYLLA, Feistm., Pl. XX, Figs. 5, 6.

*Foliis pluribus in pedunculo communi insertis, oblongis, distincte pedunculatis; nervo medio apicem versus evanescente; nervis secundariis anastomosantibus.*

I have given as complete a diagnosis as possible from the two specimens figured in the present paper, but as it is have been obliged to take some of the characters from McClelland's original specimens of *Glossopteris acaulis*, which are in our Museum, and of which it is my intention to give better figures in my monograph.

The two specimens figured from Mr. Wood-Mason's collection certainly belong to the same species.

They differ from *Glossopteris* by their net-venation and by the midrib vanishing towards the apex. The specimens here figured are basal portions of leaves and well show the stalk. Their relative position to each other on the stone is such as to lead one to suppose they were inserted on a common stalk.

With this I will rest satisfied at present. *Sagenopteris* is a Rhætic and Liassic form, and I do not think anybody can consider our form as Palæozoic.

I think that amongst the Raniganj fossils in the Geological Museum will be perhaps some more forms of this genus, but as these are still undescribed, I will not mention them here.

Of other ferns, which are also from the Raniganj group, and which I have partially described, I may on account of the connection also mention

ACTINOPTERIS BENGALENSIS, Feistm.

1876. Feistmantel Rec. Geol. S. Ind. IX. 3. p. 76.

In my note (l. c.) I have given a diagnosis of this fern and have here nothing to add. I will describe the species fully in a future paper and give a figure of it.

I now give a general list of the ferns as I did in the case of the *Equisetaceae*.

*General view of the Filices in the Raniganj field.*

Names of the species from the Raniganj field.	Where in other portions of the Damúdas and analogies in the Upper Gondwanas.	Analogies in Europe.		Analogies in Australia.
		Trias.	Jura.	
Order <i>Sphenopterides</i> .				
<i>Sphenopteris polymorpha</i> , Feistm. ....	In the Barákar group, Talchir (Cuttack) Orissa.	....	<i>Sphenopteris athyrioides</i> , Bgt. sp.	<i>Sphenopteris alata</i> , Schimp., the upper portion only.
Order <i>Pecopterides</i> .				
Group of <i>Alethopteris Whitbyensis</i> , (Schimp. 1869 Fstn. 1876) .....				
<i>Alethopteris Lindleyana</i> , Royle sp. ....	Analogous to <i>Alethopteris indica</i> , O. M., from the Rajmahal Hills.	....	} <i>Alethopteris Whitbyensis</i> , Göpp. in Lias and Oolites. <i>Asplenites (Cladophlebis) Rosserti</i> Schenk, from the Rhætic.	} <i>Pecopteris (Alethopteris) australis</i> , McCoy, from Tasmania (mezozoic).
<i>Alethopteris comp. Whitbyensis</i> , Gopp. ....	<i>Alethopteris Whitbyensis</i> in Kach. <i>Al. indica</i> , O. M., in Rajmahal Hills.	....		
Type <i>Phegopteris</i> , Mett.				
<i>Alethopteris phegopteroides</i> , Fstn. ....	....	<i>Pecopteris Stuttgartensis</i> , Bgt. (Keuper).	....	....
Order <i>Tæniopterides</i> .				
<i>Macrotaeniopteris danaoides</i> , Royle sp. ....	In the Barákar group near Burgo, (Rajmahal Hills.) Some analogy with <i>Macrot. muscifolia</i> , O. M., Rajmahal Hills.	....	Some liassic forms.	....

Names of the species from the Raniganj field.	Where in other portions of the Damúdas and analogies in the upper Gondwanas.	Analogies in Europe.		Analogies in Australia.
		Trias.	Jura.	
Macrotaeniopteris sp. ....	....	....	....	....
Type <i>Vittaria</i> , Swartz.	....	....	....	....
Genus <i>Palaeovittaria</i> nov., Fstm.				
<i>Palaeovittaria</i> Kurzi, Fstm.				
Order <i>Dictyopterides</i> .				
Genus <i>Belemnopteris</i> nov., Fstm.				
<i>Belemnopteris</i> Wood-Masoniana, Fstm. ....	....	....	....	....
Genus <i>Gangamopteris</i> , McCoy, ....	....	....	....	....
<i>Gangamopteris</i> Whittiana, Fstm. ....	Genus in the Barakars and Talchirs.	....	....	Genus in Australia (Victoria).
Genus <i>Glossopteris</i> .				
<i>Glossopteris</i> angustifolia, Bgt. ....	....	....	....	....
<i>Glossopteris</i> communis, Fstm. ....	Throughout the Damuda Series.	....	....	New South Wales ? upper coal-strata.
<i>Sagenopteris</i> polyphylla, Fstm. ....	....	....	Genus Rhætic and Liassic.	....
<i>Actinopteris</i> Bengalensis, Fstm. ....	....	....	Genus Rhætic.	....

## CONCLUSIONS.

1. Mr. Wood-Mason's collection has yielded 14 species, two belonging to the Equisetaceæ, and 12 being ferns.

2. Amongst these fourteen are two new genera (besides a new type of *Alethopteris*) and seven new species. The collection, therefore, increases considerably our previous knowledge of Raniganj plants.

3. The character of the whole flora is mezozoic. The prevalence of ferns with net-venation (not being *Glossopteris*), and the occurrence of *Taeniopteris* especially shows this.

4. But also *Glossopteris* has shown some differences as compared with those in Australia: I refer to the marginated margin in *Glossopteris*

*angustifolia*, indicating perhaps a *Pteris*-fructification, while some Kamthi specimens show a *Polypodium*-fructification, and some Australian ones show a fructification along the veins.

5. Amongst the Equisetaceae *Schizoneura* is decisive, which is so frequent in the collection of the Geological Survey.

6. Amongst the ferns the *Alethopteris phegopteroides* is very close to the living *Phegopteris*; *Belemnopteris* is very close to some living forms; *Gangamopteris Whittiana* is very close to the living *Antrophyum*; and *Palaeovittaria* is very remarkable; of importance besides these is *Macrotæniopteris danaeoides* and *Alethopteris* comp. *Whitbyensis*, Göpp.

*Alethopteris phegopteroides* reminds one also of a Triassic type, the *Pecopt. Stuttgardensis*, Bgt.

7. Mr. Wood-Mason's specimens afford strong corroboration of my views as to the mezozoic age of the Damudas in general.

8. With the lower portion of the Damudas, namely with the Barákars, the upper has *Sphenophyllum trizygia*, *Vertebraria indica*, *Sphenopt polymorpha*, *Macrotæniopteris danaeoides*, *Glossopteris communis*, and the genus *Gangamopteris*, in common; so that the close palæontological connection of the two is again seen.

9. The Kamthi group has with the Raniganj the same *Phyllothecca indica*, *Vertebraria indica*, and the same *Glossopteris communis* in common.

10. With the Australian lower coal-strata no comparison at all is possible as not one single marine animal has been met with in our Raniganj group or indeed in any part of the Damuda Series.

11. A comparison, if any, is only possible with the upper coal-beds of Australia, which alone are mezozoic and contain several fossils identical with those of our Damuda Series.

12. A complete register of the fossils from the Damúdas, including Mr. Wood-Mason's new forms, has been given by me in Records G. S. India, 1876, IX, No. 4.

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## EXPLANATION OF THE PLATES.

## Plate XV.

- Figs. 1—2. *Sphenophyllum Trizygia*, Ung. Two branchlets showing well the characteristic disposition of the leaflets in the articulation. Fig. 2a. One leaflet enlarged to show the mode of origin and the distribution of the veins.
- Figs. 3—4. *Vertebraria Indica*, Royle. Fig. 3. Good specimen, with a branch exhibiting the same characters as the main stem. This specimen is particularly remarkable, as showing distinctly enough ribs on the surface, which in several places (*a a a*) form "articulations." Fig. 4. A portion of a rootlet of the same species.

## Plate XVI.

- Figs. 1—3. *Schizoneura Gondwanensis*, Feistm., branchlets and leaflets of this important species.
- Fig. 4. *Vertebraria indica*, Royle, a stem exhibiting regular articulation, and consequently the equisetaceous nature of this fossil.
- Figs. 5—7. *Sphenopteris polymorpha*, n. sp. Fig. 5, top portion of the frond. Figs. 6 and 7, leaflets from lower portions. The rhachis broadly winged.

## Plate XVII.

- Figs. 1—3. *Sphenopteris polymorpha*, n. sp., illustrating pinnæ from different portions of the frond. Fig. 1. Top portion. Fig. 1a. A leaflet enlarged. Figs. 2 & 3. Pinna and leaflet from the lower portion of the frond. Fig. 3a. One pinnula enlarged. Rhachis broadly winged.

## Plate XVIII.

- Figs. 1. 2. *Alethopteris phegopteroides*, n. sp. A very interesting type in the group of *Pecopterides*, approaching most strikingly the living *Phegopteris*. Fig. 1. Shows a portion of the frond and the disposition of the pinnæ and the pretty thick rhachides. Fig. 2. Two entire pinnæ with their apices. Fig. 1a. Illustrates the disposition of the veins in the pinnulæ. Fig. 2a. The top portion of the pinna.

## Plate XIX.

- Fig. 1. 2. *Macrotaeniopteris (Taeniopteris) danaoides*, Royle sp. (McClell.). Two out of many other specimens. Fig. 1a. Shows the distribution and the mode of furcation of the veins.
- Figs. 3. 4. *Palaeovittaria Kurzi*, gen. et sp. nov. Fig. 3a. Shows the basal portion, with the midrib and secondary veins issuing from it. Fig. 4a. The relations of the secondary veins in the top portion.

## Plate XX.

- Figs. 1—2. *Belemnopteris Wood-Masoniana*, gen. et sp. nov. (N. B.—The two lobe-veins are a little exaggerated.) Fig. 2. Represents what is believed to be the top portion of the leaf of the same species.
- Figs. 3—4. *Gangamopteris Whittiana*, n. sp. Two specimens with very large areoles of that intermediate form between *Glossopteris* and *Cyclopteris*, which has lately proved so frequent in our Barakur group. These specimens exhibit very well the distribution of the vein-areoles in two directions towards the margin without any midrib.

Figs. 5—6. *Sagenopteris polyphylla*, n. sp. These two specimens belong, I believe, to that form which McClelland first mentioned as *Glossopteris acaulis*, which, however, I consider to be a *Sagenopteris*.

Plate XXI.

Fig. 1. *Macrotaeniopteris danaeoides*, Royle sp. a portion from the middle part of the leaf enlarged to show the development of the secondary veins from the midrib.

Figs. 2—4. *Glossopteris angustifolia*, Bgt. Fig. 2. A nearly complete leaf with base and apex. Figs. 3 and 4 top portions of the leaf—all exhibiting the marginated margin which probably indicates the fructification—which in this case would be a “fructificatio-Pteridis.” Fig. 2a. A portion, enlarged to show the veins and the marginal smooth longitudinal portion of the leaf.

Fig. 5. *Glossopteris communis*, n. sp. A portion of a *Glossopteris*, which is very frequent throughout the Damuda Series.

Fig. 6. *Alethopteris Whitbyensis* (?), Göpp. Two pinnulæ belonging most probably to this mezozoic species.

